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Military Uses of Television

These papers were solicited and grouped chiefly for presentation during two sessions at the Society's Convention in Philadelphia in October 1957 to inform Society members about the utilization of television by the military services and the diversity of its application; and to indicate the potential value of television to the military. Some of the papers describe specific equipment or technique developments which enhance the value of television equipment in the military applications. — *Max C. Batsel*, Program Topic Chairman.

Pickup Tube Performance With Slow Scanning Rates

By CHARLES T. SHELTON and H. W. STEWART

For military purposes it is often desirable to operate a TV system at nonstandard scanning rates. This paper describes a study performed for the U. S. Army Signal Engineering Laboratories, Fort Monmouth, N. J., of the operation of standard image orthicons and vidicons at reduced rates. Resolution, sensitivity and other characteristics of these tubes have been measured. Characteristics desired for tubes designed particularly for slow-scan operation are considered.

In a great many military and industrial television applications, system requirements permit, and often necessitate, operation at nonstandard rates. In this paper "standard rates" implies commercial broadcast TV scanning standards. Many military and industrial systems cannot provide the bandwidth of 4 to 6 mc imposed by standard rate operation, but do require exploitation of the resolution capabilities of the pickup device.

Two advantages are gained by slow scanning rates: decreased bandpass requirements and increased sensitivity in pickup tubes. These will be considered in detail in this paper. Useful sensitivity is here defined in terms of signal-to-noise ratio for a given light level since image noise is usually the factor which determines the lowest light level at which a pickup tube can be used. Some disadvantages of slow-scan operation are: image smear resulting from longer storage time, low information rates and display flicker. Image smear is the same phenomenon as is encountered in photographing objects in motion and, as in photography, it may be compensated by the use of high-speed shutters at the cost of reduced useful sensitivity.

The reduction in number of complete pictures per second in slow-scan operation is a reduction in information rate. The seriousness of this effect depends upon the nature of the scene being viewed and the use to be made of the image. In some cases the scene changes slowly and frame rates of one/sec or one/min are capable of relaying all available information. In other cases, such as when the camera is on a rapidly moving platform, it is desirable to have the repetition rate high enough to preserve the illusion of continuous motion in order to obtain the maximum amount of information.

Display is a difficult problem with slow scanning rates. If a kinescope with a long

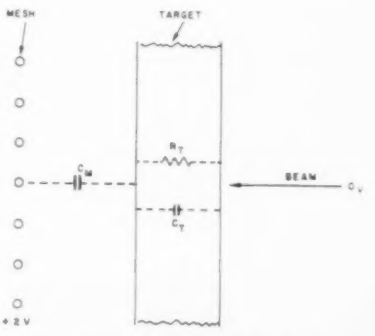
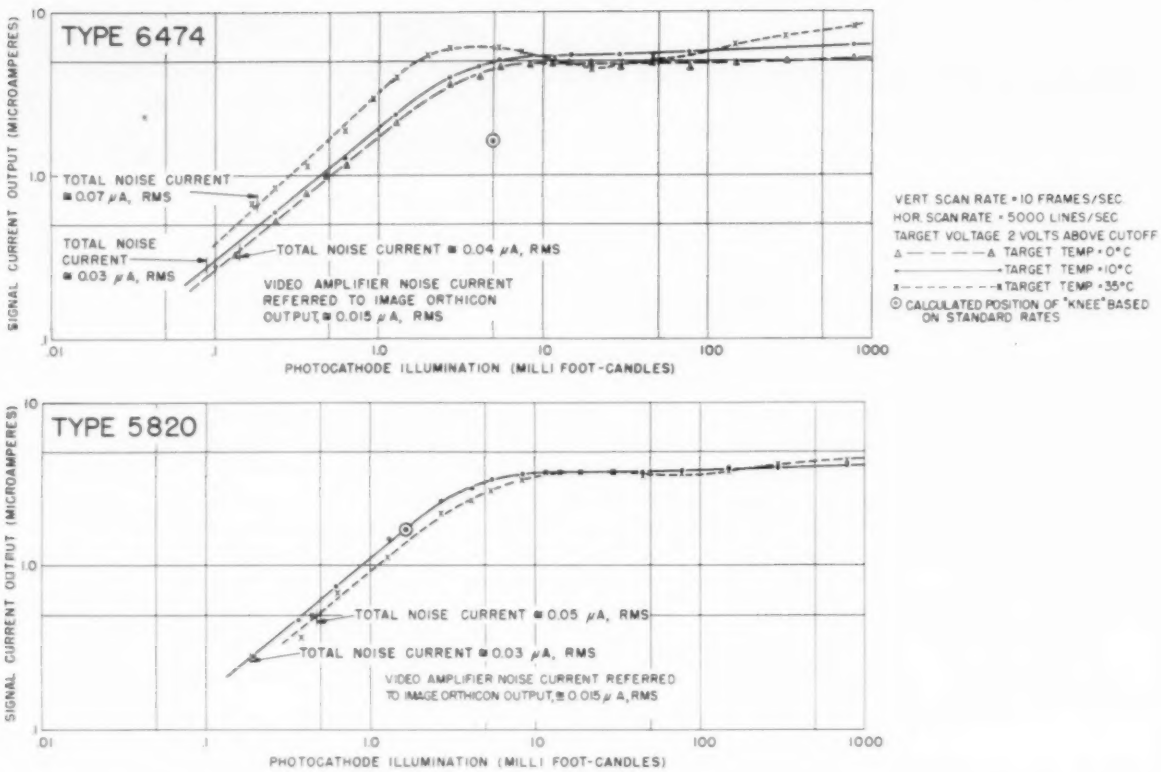


Fig. 1. Equivalent circuit of image-orthicon target.

Presented on October 7, 1957, at the Society's Convention at Philadelphia by Charles T. Shelton (who read the paper) and H. W. Stewart, Radio Corp. of America, Defense Electronic Products, Camden 2, N.J.
(This paper in final form received May 21, 1958.)


TYPE 6474
SIGNAL CURRENT OUTPUT (MICROAMPERES)
TOTAL NOISE CURRENT ≅ 0.07 μA, RMS
TOTAL NOISE CURRENT ≅ 0.03 μA, RMS
TOTAL NOISE CURRENT ≅ 0.04 μA, RMS
VIDEO AMPLIFIER NOISE CURRENT REFERRED TO IMAGE ORTHICON OUTPUT ≅ 0.015 μA, RMS
PHOTOCATHODE ILLUMINATION (MILLI FOOT-CANDLES)
VERT SCAN RATE = 10 FRAMES/SEC
HOR SCAN RATE = 5000 LINES/SEC
TARGET VOLTAGE 2 VOLTS ABOVE CUTOFF
Δ — — — — Δ TARGET TEMP = 0°C
• ——— • TARGET TEMP = 10°C
x - - - - - - x TARGET TEMP = 35°C
⊙ CALCULATED POSITION OF "KNEE" BASED ON STANDARD RATES
TYPE 5820
SIGNAL CURRENT OUTPUT (MICROAMPERES)
TOTAL NOISE CURRENT ≅ 0.05 μA, RMS
TOTAL NOISE CURRENT ≅ 0.03 μA, RMS
VIDEO AMPLIFIER NOISE CURRENT REFERRED TO IMAGE ORTHICON OUTPUT ≅ 0.015 μA, RMS
PHOTOCATHODE ILLUMINATION (MILLI FOOT-CANDLES)

Figs. 2A and 2B. Image-orthicon light transfer curves at 10 frames/sec.

persistence phosphor is used the brightness of the display is nonuniform in the same manner as a radar PPI display. It is possible to obtain constant brightness using a storage tube of some type but this approach adds extra equipment to the system and, in most cases, reduces image quality.

Although video amplifier and deflection circuit techniques are straightforward, little has been known in the past about the operation of pickup tubes at nonstandard rates. This paper reports some results of a study of the operation of the image orthicon and vidicon at slow scanning rates.

I. THE IMAGE ORTHICON

In spite of the complex circuitry and demanding power supply requirements of the image orthicon, the superior performance of this tube has made it the most popular pickup device for commercial applications. A number of military and industrial systems have requirements such as maximum sensitivity, maximum resolution, or minimum image lag, which can only be satisfied by the image orthicon.

A. Theory of Operation

In order to get some detailed understanding of what might be expected at slow scan rates, consider the operation of the target, which is the only portion of the device markedly affected by a change in scanning rates. Figure 1 illustrates a small portion of the target and mesh and shows its electrical equivalent circuit. C_m is the capacity between the target and mesh and C_t and R_t are the capacitance and resistance per unit area between surfaces of the glass target.

When the element is scanned by the beam, the rear side of the target is brought to zero volts. Since the mesh is at some positive potential (+2 volts in practice), the front side of the target is at some potential determined by the divider action of C_t and C_m. At scanning rates of interest R_t has no appreciable effect on the capacitor divider effect. C_t is in practice much greater than C_m so the front side of the target is at a very low potential.

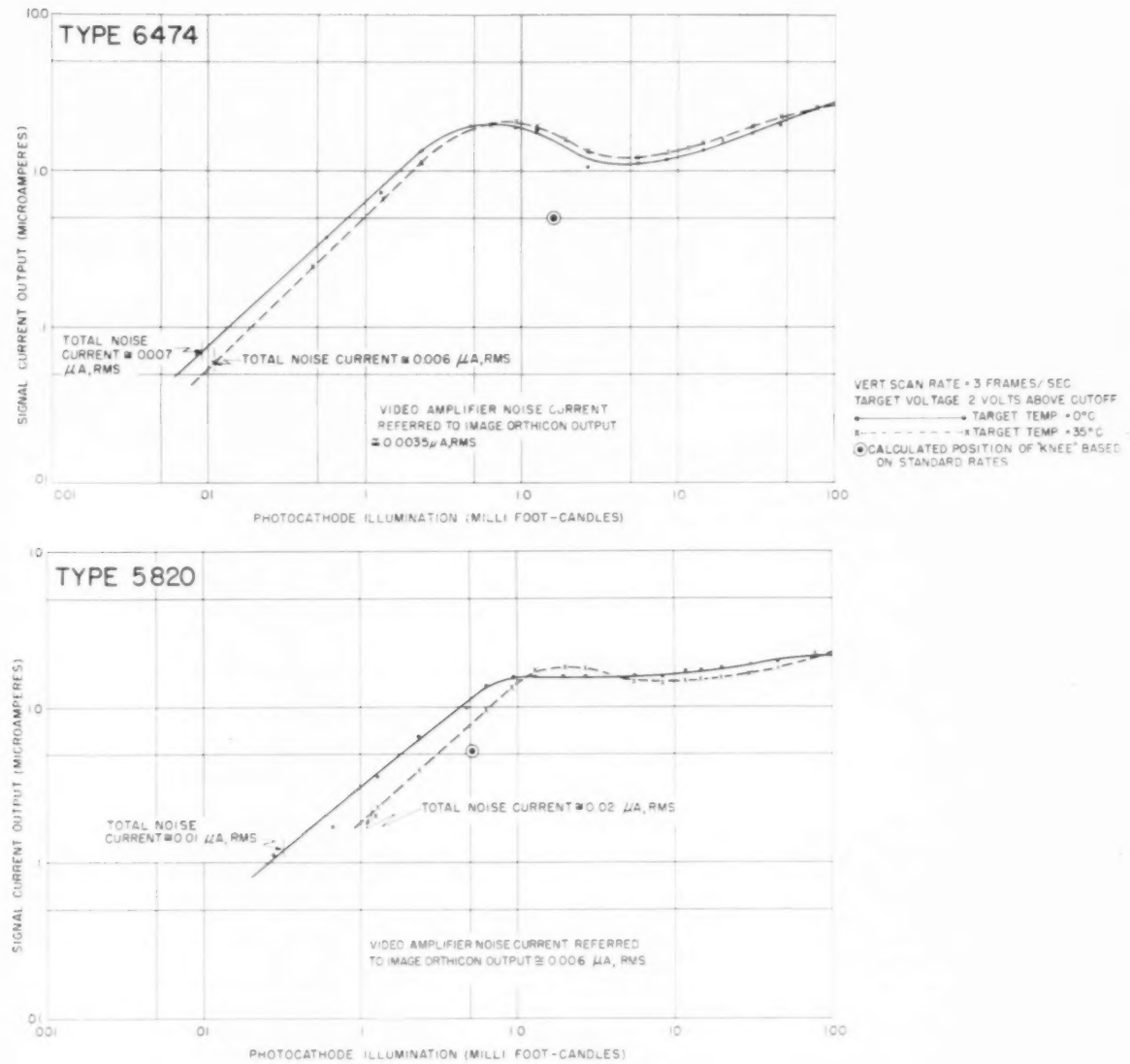
During the interval between scans, electrons arriving at high velocity from the photocathode cause secondary emission from the target. The secondary electrons are collected by the mesh, leaving a positive charge on the target. Also during this interval, the drop across C_t discharges through R_t.

When the beam again scans the target, enough electrons land to recharge the scanned side to zero volts, and the remaining beam electrons are repelled and return to the electron multiplier as signal. The output signal, therefore, is proportional to the potential of the scanned side of the target.

Maximum signal occurs when the target charges to the mesh voltage. An increase beyond this light value causes secondary electrons to redistribute on the target. Peak signal does not increase, although contrast between adjacent areas is maintained. The value of 2 v for the mesh is selected to keep to a minimum bending of the low-velocity scan beam by nearby elements which are at the mesh potential.

If R_t is too large, the time constant $R_t C_t$ will be great compared with the time between scans and a loss of signal will result. If R_t is too small, it follows that with conventional target materials the resistivity is low, and conduction between adjacent elements will cause a severe loss of resolution.[1] The transverse resistivity may become smaller due to another effect; cesium from the photocathode may migrate to the target surface.

If we assume that the target charges linearly with time, i.e., that the light level is not so high that saturation occurs, we can make some predictions about operation at slow scan rates where both horizontal and vertical rates are reduced proportionally. It is assumed that the time constant $R_t C_t$ is small with respect to frame time. Since the usable signal is derived by discharging a capacitance, the signal will decrease with an increase in frame time for constant target charge. The target charge at a given light level



Figs. 3A and 3B. Image-orthicon light transfer curves at 3 frames/sec.

will increase in direct proportion to frame time, so that the signal output for a given light level will remain constant. Assuming a constant target charge, the signal currents will vary inversely as frame time T,

$$S \propto \frac{1}{T}$$

Also, an inverse relation exists between light level L and frame time,

$$L \propto \frac{1}{T}$$

If the number of raster lines is held constant, the bandwidth B will also vary inversely as T,

$$B \propto \frac{1}{T}$$

The practical limit to sensitivity is the thermal noise of the beam, which has a flat frequency spectrum. The noise N will therefore vary as

$$N \propto \sqrt{B}$$

for constant beam current.

However, since the beam current and consequently beam noise must increase with signal, noise will also vary as $N \propto \sqrt{S}$ for a constant bandwidth. Since $S \propto \frac{1}{T}$ then as frame rate changes,

$$N \propto \sqrt{\frac{1}{T}}$$

for constant bandwidth. As frame rate and bandwidth are decreased together,

$$N \propto \sqrt{\frac{1}{T}} \sqrt{\frac{1}{T}} = \frac{1}{T}$$

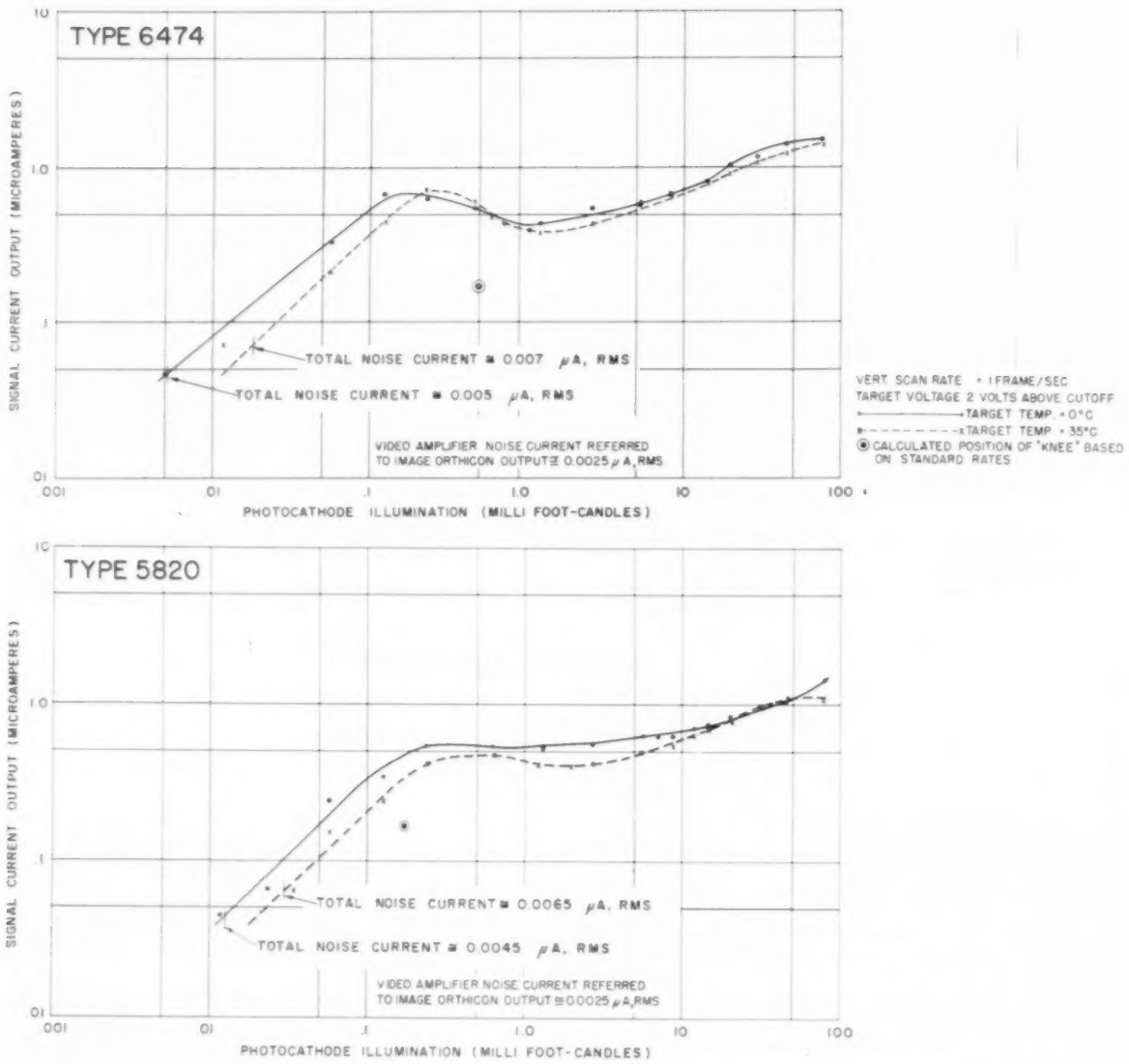
and

$$\frac{S}{N} \propto \frac{1/T}{1/T} = \text{constant}$$

We can conclude that, for operation at a light level producing constant target charge, the signal-to-noise ratio will remain constant as scan rate changes, and that the light level required will be reduced in direct proportion to frame rate. The useful sensitivity will therefore be increased. This conclusion is based on the assumption that linear storage occurs, and that beam noise has a flat spectrum. Both assumptions are only approximate.

B. Experimental Results

The object of the tests was to measure the curve of signal current vs. light level and resolution of the RCA-5820 and RCA-6474 image orthicons at various scan rates. The signal vs. light level curves were taken while the camera tube was imaging a uniform white surface of variable brightness in the



Figs. 4A and 4B. Image-orthicon light transfer curves at 1 frame/sec.

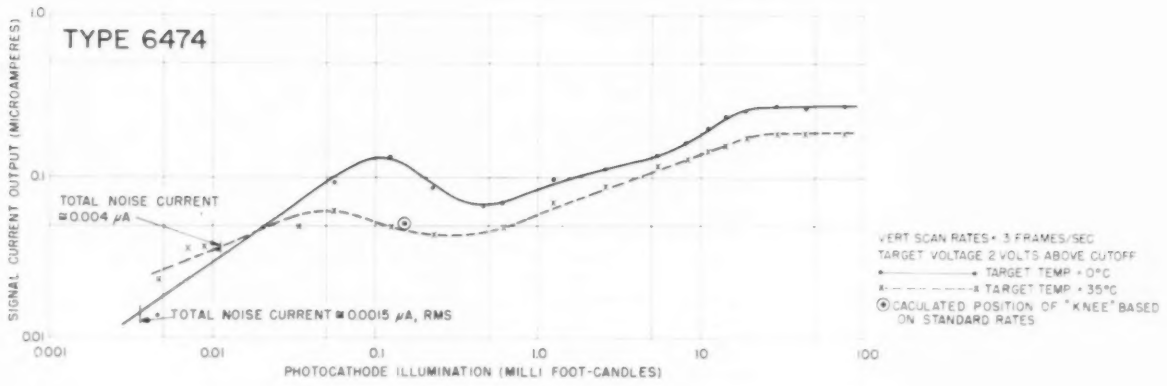
center of which was a large black area. The signal current was the change in current output from the tube occurring at the transition between the white and black areas. The error introduced by the reflectance of the black surface (approximately 3%) was not a significant part of the overall experimental error.

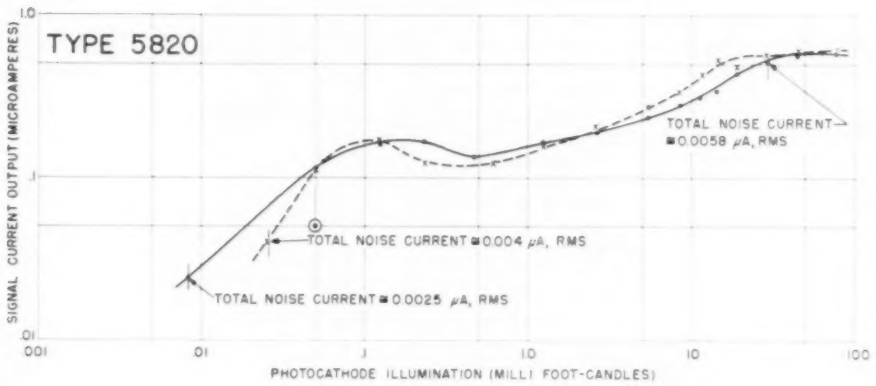
In this paper the quantity "resolution" is defined by the aperture response curve of the component or system in question.[3,4] In most descriptions of TV systems the quantity given is "limiting resolution" which does not accurately specify image quality. It is only one point on the aperture response curve and changes with noise level. The aperture response curve is determined by measuring the response to patterns whose brightness varies sinusoidally along the axis of scanning. When a single number for resolution is desired the equivalent optical passband, N_e, is used.

All measurements were made with continuous scan and exposure. At all rates a 500-line, noninterlaced raster was maintained. Therefore, the bandwidth required varies directly with frame rates. The bandwidth selected for each rate was that calculated on the basis that a 10-mc bandwidth is required (to exploit fully resolution capabilities — as distinguished from use for broadcast television) for the standard 30-frames/sec (525-line) raster. Image orthicons are capable of producing video components of this frequency and in some cases even higher frequencies. The bandwidths were 3.18-mc, 955-kc, 318-kc and 95-kc for respective rates of 10, 3, 1, and 0.3 frames/sec. In making measurements of noise level, the bandwidth was limited so that unnecessary noise would not be introduced. Simple R-C filtering was used in all cases. If filters with sharper rolloff were used some reduction in noise could be obtained. The preamplifier had been adjusted to be flat to 6 mc with the high peaker disabled. After placing the camera in operation, the high peaker was adjusted by visual observation for optimum transient response to a step function.

(1) Image-Orthicon Light Transfer Characteristic Curves

Of prime importance in expressing quantitatively the operation of a pickup tube is the curve of its signal-current output as a function of the light level incident upon the photocathode. This curve, combined with an evaluation of signal-to-noise ratio, indicates the useful





Figs. 5A and 5B. Image-orthicon light transfer curves at ⅓ frame/sec.

operating range and maximum sensitivity of the tube. The illumination used was tungsten (about 2800 K) and was measured with a visual comparison illuminometer.

Two common types of image orthicons were evaluated in this study. The 5820 is the tube which is commonly used for field applications in black-and-white studio service. When operated at standard rates the target reaches saturation (known as the "knee") at an average value of 0.01 ft-c on the photocathode, giving a signal current of about 10 μa. The 6474 was developed for the three-tube color camera. This tube has a higher capacity target C_m, due to closer target-to-mesh spacing, resulting in a higher signal-to-noise ratio at the knee and a greater linear operating range. The knee occurs at an average value of 0.04 ft-c.

The two tubes used in the study proved to differ somewhat from average. It happened that the 5820 used was somewhat less sensitive than average while the 6474 was more sensitive than average as given in RCA Tube Dept. data. The result was that the knee of the 6474 occurred at a somewhat lower light level than the knee of the 5820 even though it was a higher capacity tube. Since there are a large number of internal factors which can affect the sensitivity of the image orthicon, it is not surprising to find considerable tube-to-tube variation. It happens in this case that the variations in manufacture overcame the difference caused by the variation in target capacity. This discrepancy is of no particular consequence in the study since trends, rather than absolute values, are of significance.

Figures 2 through 5 indicate the variation in signal vs. light level characteristic as the scanning rate is varied from 10 frames/sec to 0.3 frame/sec. Ten frames/sec was chosen as a rate near enough to standard to give continuity of data. The lower limit was a more or less arbitrary choice based on equipment convenience. There is no reason why the tube cannot be operated at lower rates, and, in fact, some qualitative tests were made at rates as low as one frame/min. The tube works very well at these rates if enough light is available to provide continuous secondary redistribution on the target to maintain resolution. It would, however, require a considerable increase in resistivity for the target to store an image for a full minute. It has been estimated that resistivity, R_t, is doubled for each 10 C temperature change. Adequate resistivity was achieved at −10 C to give a good picture at light levels below the knee at 0.3 frame/sec, but degradation at lower rates was observed indicating that even lower temperatures were required.

The curves for 10-frames/sec operation (Figure 2) are, as expected, very similar to those for standard rates. The knee has shifted to a lower light level. The expected positions of the knee for slow-scan operation are indicated on the figures. These were calculated assuming linear storage and an initial signal current of 10 μa. RCA Tube Handbook values of 0.04 ft-c and 0.01 ft-c (for the 6474 and the 5820, respectively) were assumed for the tubes for standard rates. In Fig. 2 it can be noticed that, as described above, the 5820 knee is above the calculated light level, and the 6474 knee is below the calculated light level. This trend is continued, in general, for all rates. Also, the absolute signal current output at the knee is above the expected value for both tubes. This may be due to slight variations of multiplier voltage, among other things, since signal current is a function of multiplier voltage.

At a rate of 3 frames/sec (Fig. 3) a change in the nature of the signal vs. light level characteristic curve can be noticed. The knee still occurs near the predicted value of light level, but at higher light levels the signal current tends to drop slightly, followed by a rise to values higher than that found at the knee. This trend is most pronounced with the 6474 and exists for rates of 3 frames/sec and below.

It is normally assumed that the output of the image orthicon increases with light level until the target-to-mesh capacity is fully charged. At this point the peak sig-

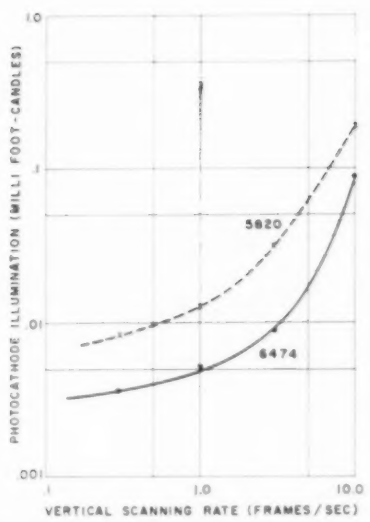


Fig. 6. Image-orthicon photocathode illumination for a signal-to-noise ratio of 10; target temperature established for minimum lateral leakage.

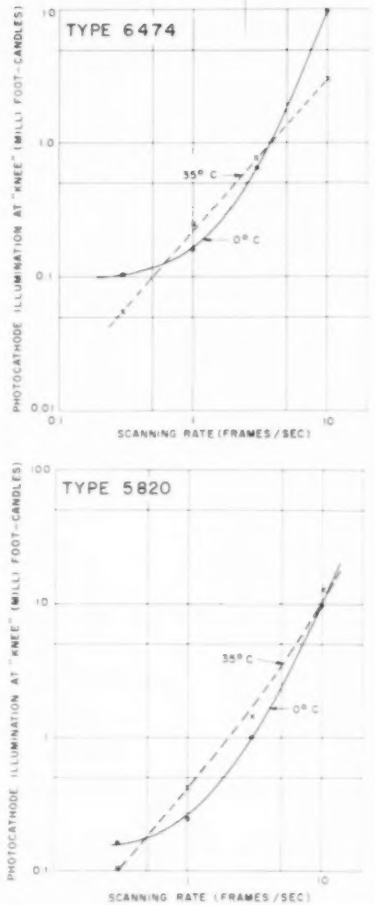
nal output remains constant although contrast is maintained by redistribution as light level is further increased. However, in early work on the image orthicon it was found that, under some conditions, after the first knee had been passed the signal current would exhibit a second rise followed by a second knee.[4] This effect was associated with the free space capacity of a small area of the target. It was considered that this free space capacity had a value different from the target element-to-mesh capacity and might therefore be charged to a higher voltage at a higher light level. In any event it was apparent that the target was receiving a greater charge than might be expected considering the equivalent circuit in Fig. 4.

The phenomenon of the second knee is not evident in the normal operating range of the present image orthicons at standard rates. However, it is evident that by operating at reduced rates the effect has been encountered again. The target is charging to a higher potential than at the first knee thus giving an increased signal. At rates of 1 and 0.3 frames/sec there is a pronounced second knee beyond which the signal no longer increases.

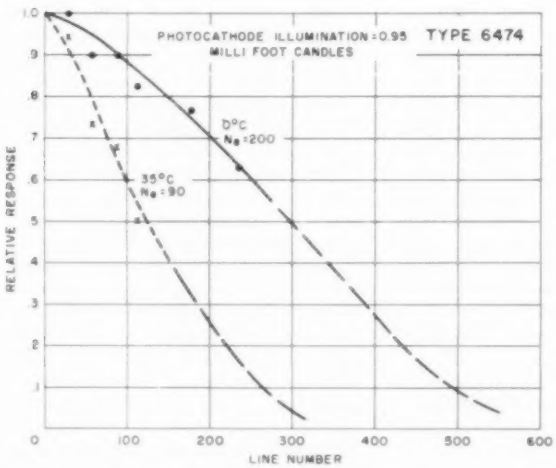
As expected, the sensitivity of the tube continues to increase as lower scan rates are used. Figure 6 indicates the relationship between the scan rate and light level required for a 10 to 1 signal-to-noise ratio. At the lower signal currents, it was found that the preamplifier was contributing an appreciable part of the system noise. Amplifier noise was not considered in the relationships developed previously and accounts, in part, for the departure from linearity of the curves. Some improvement in sensitivity could be obtained by using a low noise preamplifier circuit such as is used in vidicon cameras.

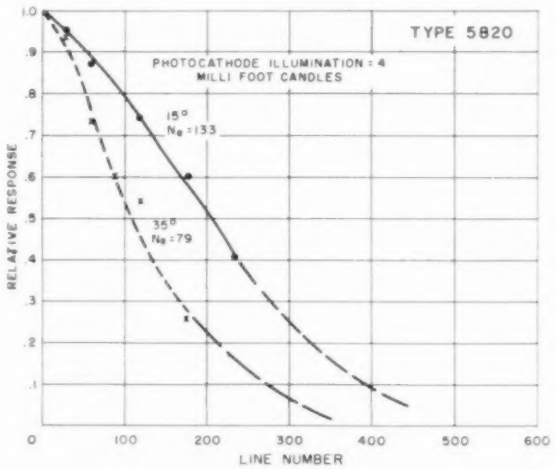
For signal-to-noise ratios of 10 and below and for operation at the lower temperatures, the preamplifier noise was of the order of one-half to three-fourths the value of the total noise. This gives a preamplifier contribution to the total noise at low light levels of approximately 10 to 35%, assuming that the beam noise is equal to the square root of the difference of the squares of the total noise and the preamplifier noise. Of course, beam noise became the determining factor of the signal-to-noise ratio when the image orthicons were operated at higher light levels.

Figure 7 indicates in a general way how the first knee varies with scan rate. It can be seen that storage is reasonably linear for higher temperature operation and less linear at 0 C. The reason for departure from linearity in this case is not clear. It should be remembered in making calculations of this sort that the effective storage time at standard rates is $\frac{1}{60}$ sec, not $\frac{1}{30}$ sec, as ordinarily supposed. This is due to the fact that in the image orthicon the beam width is sufficient to discharge every element of the target during each 250-line field with interlaced scanning. Very little target charge remains after the first field to be read out during the second field.

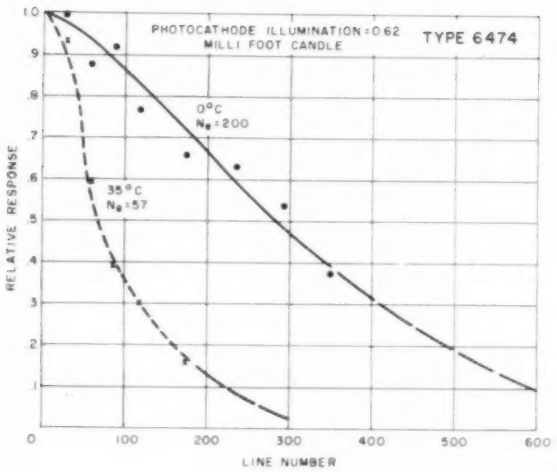


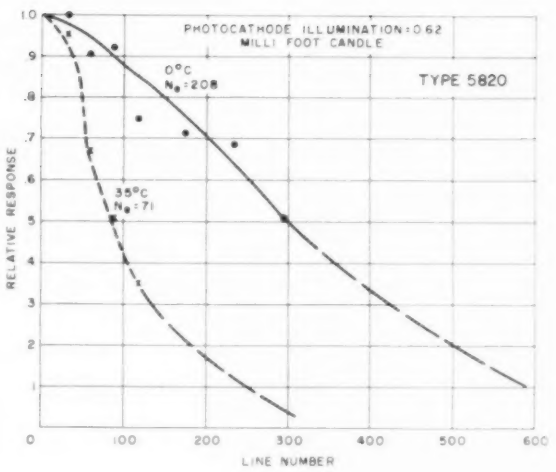
Figs. 7A and 7B. Image-orthicon light saturation level (first knee) vs. scan rate.





Figs. 8A and 8B. Image-orthicon aperture response at 10 frames/sec.





Figs. 9A and 9B. Image-orthicon aperture response at 3 frames/sec.

(2) Resolution

Figures 8 and 9 indicate the aperture responses of the two pickup tubes at the various rates. Viewing the resolution curves as a whole the reader can see the pronounced effect of temperature on resolution. It is obviously essential to increase the resistivity of the target to obtain adequate picture quality.

The variation of resolution with temperature is a gradual effect. It is difficult to determine at exactly what temperature the resolution becomes maximum. For this reason most of the high resistivity measurements were taken at 0 C since the resolution did not improve below this temperature at any rate. However, in operating the image orthicons at each rate, an attempt was made to find the temperature above which resolution degradation becomes evident. This temperature was between 15 and 20 C for 10-cycle operation, between 5 and 10 C for 3 cycles, between 0 and 5 C for 1 cycle, and approximately 0 C for operation at 0.3 cycle. It is indicated in the published tube data that, at standard rates, resolution begins to decrease at about 35 C. These values can serve as a general guide in determining the target resistivity required.

The fact that the N_e of the tube indicated in Figure 8 is lower than normal for the image orthicon is not because of the higher temperature. Both tubes operated in the cold box suffered a permanent loss of resolution as indicated by measurements in a standard camera made after the slow scan measurements. Apparently the reduced target temperature caused an increased condensation of cesium on the scanned surface, resulting in greater lateral leakage. The curves in Figs. 8 and 9 were taken after some preliminary testing and therefore show some permanent degradation. Since the curves at different rates reflect different amounts of permanent damage they are only meaningful in showing the effect of temperature at a given rate. It would be desirable to obtain data before any permanent damage occurred but since cesium migration is a rather rapid phenomenon, a large number of tubes would be required.

One problem which becomes pronounced at lower rates is the appearance of the target mesh shadow. As the beam current is reduced the beam apparently becomes finer and the mesh signal increases considerably above the amount usually seen at standard rates. Unfortunately, the finer beam does not improve image resolution by the same amount since the image section becomes the major resolution limitation. The strong mesh pattern prevented the measurements of aperture response at higher line numbers. For this reason many of the curves are extrapolated rather than measured above 350 lines.

(3) Possible Tube Improvements

A recent development in image orthicons is the RCA-6849. This tube has a wider spacing between the target and mesh and consequently a lower value of C_m. The result is a tube which is somewhat more sensitive than the conventional image orthicon. In systems where extreme sensitivity is required, a combination of the wide-spaced image orthicon and reduced scan rates may be used to advantage.

For ultimate performance, a higher surface resistivity target is necessary. Glass is presently used, but due to the high scan rates in normal operation, an effort is made to keep the resistivity low so that the time constant $R_t C_t$ is sufficiently low. In slow-scan operation, this time constant may be increased with no degradation of signal, and a considerable improvement in resolution will be obtained since the lateral resistivity will be increased.

II. THE VIDICON

The vidicon is highly desirable in a great many industrial and military applications since it is smaller, more rugged, and requires considerably less supporting circuitry than the image orthicon. However, its lower sensitivity and resolution, and high image lag at low light levels, often prevent its use. Slow-scan operation offers the possibility of increased sensitivity and resolution, and a considerable reduction of lag per frame.

A. Theory of Operation

Because the vidicon is a less complex device than the image orthicon, it might be expected that it would be easier to predict the vidicon's performance under unusual conditions. But the vidicon is basically a semiconductor, and the action of semiconductors is not completely understood, so this is true to only a limited extent.

The target of the vidicon is a layer of photoconductive material coated on a transparent conductive surface on the

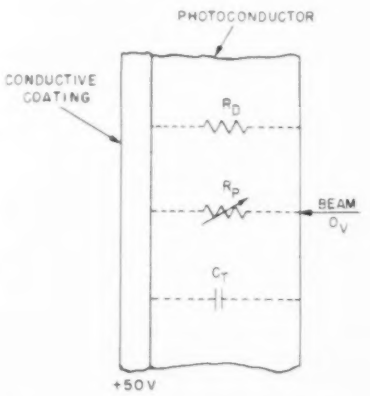


Fig. 10. Equivalent circuit of vidicon target photoconductor.

front of the tube. A small area of the target may be considered as having the equivalent circuit shown in Fig. 10. There is a capacitance C_t from one side of the target to the other, and essentially two resistive components, R_d and R_p. R_p is the photosensitive component which accounts for the light sensitivity of the tube. One side of C_t is held to the potential of the conductive signal plate, which may be about 50 v. The other side of C_t is charged to 0 v each time the beam scans that part of the target. The value of R_p changes with light level so that C_t discharges between scans an amount depending on the incident light. The current required to charge C_t to 0 v is the useful output signal. However, besides R_p, there is a fixed component R_d which does not vary with light level. Therefore, even when there is no light there is a certain amount of discharge of C_t between scans resulting in a fixed level of output signal added to the desired signal. This signal is known as dark current.

The vidicon like the image orthicon, will produce a constant signal current for a given light level regardless of scanning time, assuming linear storage; therefore, the increase in useful sensitivity with slower scanning rates is due to reduced bandwidth requirements, and a consequent reduction in noise.

There are undesirable results due to slow-scan operation. There is some tendency for lateral charge leakage to degrade resolution as it did in the image orthicon. In present tubes the loss of resolution due to lateral leakage does not appear to be serious at the rates considered.

A more serious problem is the effect of dark current at reduced scanning rates. As the time between scans is increased, the charge on C_t due to dark current alone becomes a significant part of the output signal. If dark current were uniform over the whole target it would merely add a d-c component to the signal. In practice, however, it is not uniform, and adds an undesired shading and spot pattern to the image. At standard rates and a target voltage of 50 v, the dark current is not considered objectionable. However, at reduced rates it can be greater than the signal and can cause serious interference in the image.

Besides adding a spurious pattern, dark current has another undesirable effect. In a low-velocity scanning tube such as the vidicon it is desirable to prevent the target from rising more than a few volts positive with respect to the cathode. In the image orthicon, for example, the target mesh is set at +2 v. If the voltage is permitted to go higher the beam becomes subject to distortion by local fields on the target, and does not land in a well-focused spot; therefore, resolution is decreased. In normal operation of the vidicon the light level is kept low enough so that excessive target discharge cannot occur. However, at reduced rates the target voltage can reach an excessive value due to dark current alone so that resolution is lost no matter what the light level.

The dark resistivity of the target varies with signal electrode voltage so that by reducing the voltage, the signal-to-dark current ratio can be increased. At reduced scan rates the excessive dark current can be controlled in this manner, although the signal output and therefore the sensitivity of the tube is reduced. Obviously, the target voltage must be a compromise value depending on both factors.

As with the image orthicon, some predictions can be made as to the change of sensitivity with scan rate based on the assumption of linear storage. It is known that the signal buildup in the vidicon is by nature of R-C discharge and will therefore not be linear. However, if the potential shift of the target is limited to a small amount of the total target electrode potential, as is desirable, operation will be a reasonably linear part of the charging curve. Another cause of nonlinearity is the possibility that the change of R_p is not a linear function of light. It has, in fact, been found that with standard operation the vidicon has a gamma of 0.7.

Although it is apparent that the tube does not give linear storage it is of interest to gain some idea of the expected relative increase of sensitivity as rate is reduced using this assumption.

The significant noise source in the vidicon system is the first stage of the video amplifier. The noise level, therefore, does not depend upon the beam current as in the image orthicon. In practice, the vidicon load resistance is chosen large enough that the target and amplifier input capacity is the only significant part of the load impedance over most of the video passband. After equalization, the noise voltage exhibits a linear rise with frequency, therefore

$$N \propto B^{1/2}$$

where N is the noise voltage and B is the bandwidth. Since the latter is inversely proportional to frame time T, and the signal current S is also inversely proportional to T, we find

$$\frac{S}{N} \propto \frac{1/T}{(1/T)^{1/2}} = \sqrt{T}$$

assuming the charge variation on C_t is held constant as the frame time is varied. Since the light level required for a given charge variation on C_t varies proportionally with $1/T$, the light required is reduced and the signal-to-noise ratio is increased with reduced scan rate and bandwidth. To express it another way, for constant signal-to-noise ratio the light required is:

$$L \propto \frac{1}{T^{1/2}}$$

Therefore, ignoring such problems as dark current, we expect a greater than linear increase of sensitivity with frame time.

At standard rates it is necessary to consider photoconductive lag as the major limitation on vidicon sensitivity. However, lag is a function of the light level and the properties of the photoconductor and not the scanning process so that at rates much below standard the lag per frame is small. Under such conditions thermal noise is the important sensitivity limitation.

B. Experimental Results

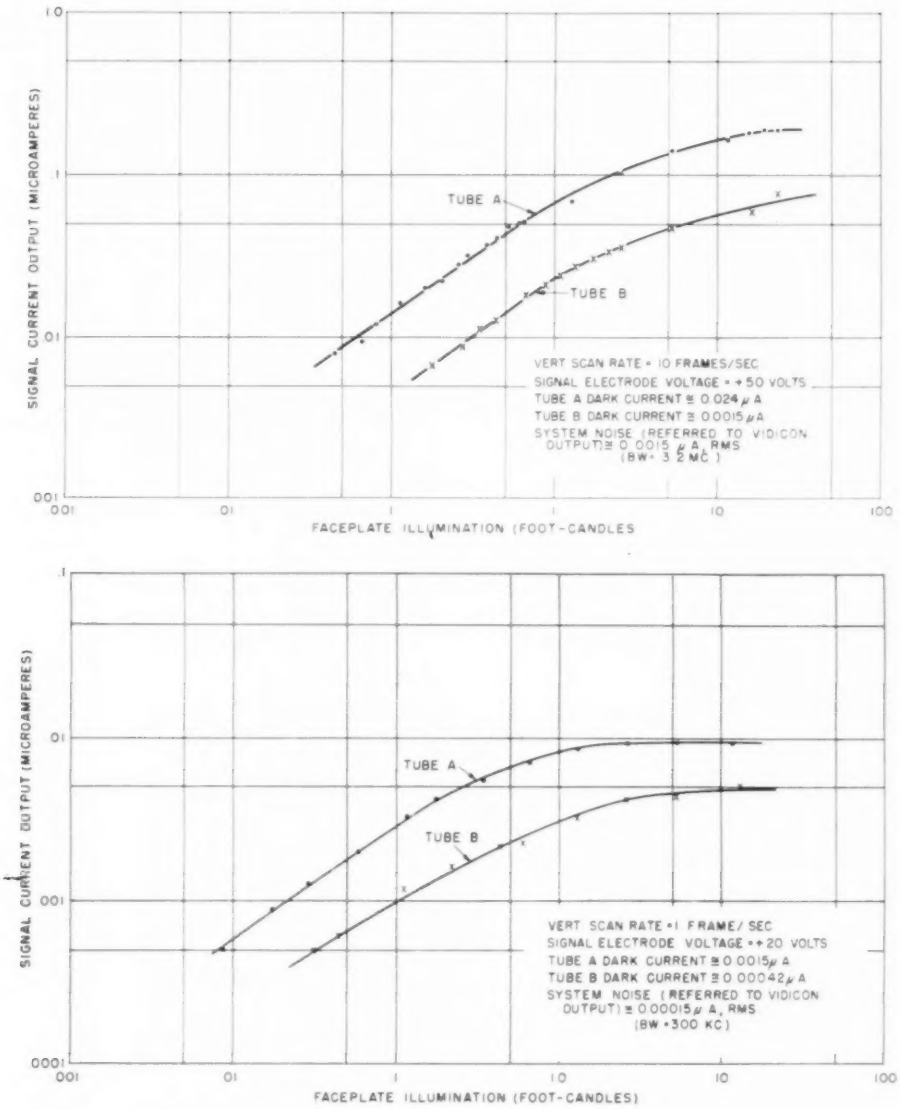
The procedures used for signal vs. light characteristic and resolution measurements were the same with the vidicon as with the image orthicon. A major problem in adjusting the vidicon at the various scan rates is to find the best compromise for target voltage. At low rates and high target voltages the dark current pattern became objectionally strong and, in some cases, the high target modulation affected resolution. However, any decrease of target voltage reduced sensitivity. During the experiments the voltage adjustment was done by observation of the monitor to determine when the dark current pattern or resolution loss became noticeable. Until a more clearcut criterion is found for establishing the optimum target voltage, this technique will probably be used in practical system operation. Because of the guesswork involved in target voltage setting, the relationship between sensitivity and frame rate which resulted does not follow a particularly smooth curve.

It should be brought to the attention of the reader that the frame rates used with the vidicon were not the same as those with the image orthicon. The vidicon data were obtained at rates of 10, 1, $\frac{1}{5}$ and $\frac{1}{20}$ frame/sec, with a 500-line, noninterlaced raster.

(1) *Modes of Operation*

The vidicon, like the image orthicon, need not always operate with full frame storage; however, the mechanism by which its storage time is reduced is somewhat different. There are two possible ways in which it might operate.

Let us assume that because of dark current, or because of a high overall light level on the target, the entire scanned side of the target has time to charge completely to signal electrode potential between scans. When the beam then scans the target it sees a uniform potential and therefore no signal. However, if a normal number of raster lines is being used the beam is wide enough to overlap adjacent lines. While the beam is scanning one line it also partly covers the line above it which it has just scanned. Therefore, a given point on the target is scanned twice by the beam on successive lines. If the point has been charged to signal electrode potential between frames it will be brought to cathode potential on the first



Figs. 11A and 11B. Vidicon light transfer curves at 10 and 1 frame/sec.

scan. Between line scans it will have time to store a signal which will be read out on the second scan.

The output of the tube will have two components: a large d-c component from the part of the beam which is charging the target to zero, and a signal component which results from that part of the beam which is reading a previously charged part of the target. This type of operation is known as line sensitivity, since the tube is only sensitive for one line period. When operating at slow rates it is easy to determine if a tube is giving line sensitivity. If an object is moved slowly in front of a line-sensitive tube it will appear as a series of sharp images. If the tube is frame sensitive, however, the object will appear as a continuous smear.

A disadvantage of line-sensitive operation is that it requires high beam current relative to the signal output. The result is somewhat reduced resolution and increased dark current shading and spots. Also, the storage time is reduced from frame time to the frame time divided by the number of raster lines. No data were taken on the resolution of the vidicon with this mode of operation.

Line-sensitive operation, brought about from two different causes, was encountered. If the scene is illuminated so that both light and dark areas are at a high enough level to discharge the target between frames, line sensitivity is obtained. Also if the dark current happens to be high enough to discharge the target between frames by itself then line sensitivity will be obtained regardless of the light level. At the upper end of some of the light transfer characteristic curves at least partial line sensitivity occurred due to high light level. However, neither of the tubes used for data taking gave line sensitivity due to dark current alone at the rates considered.

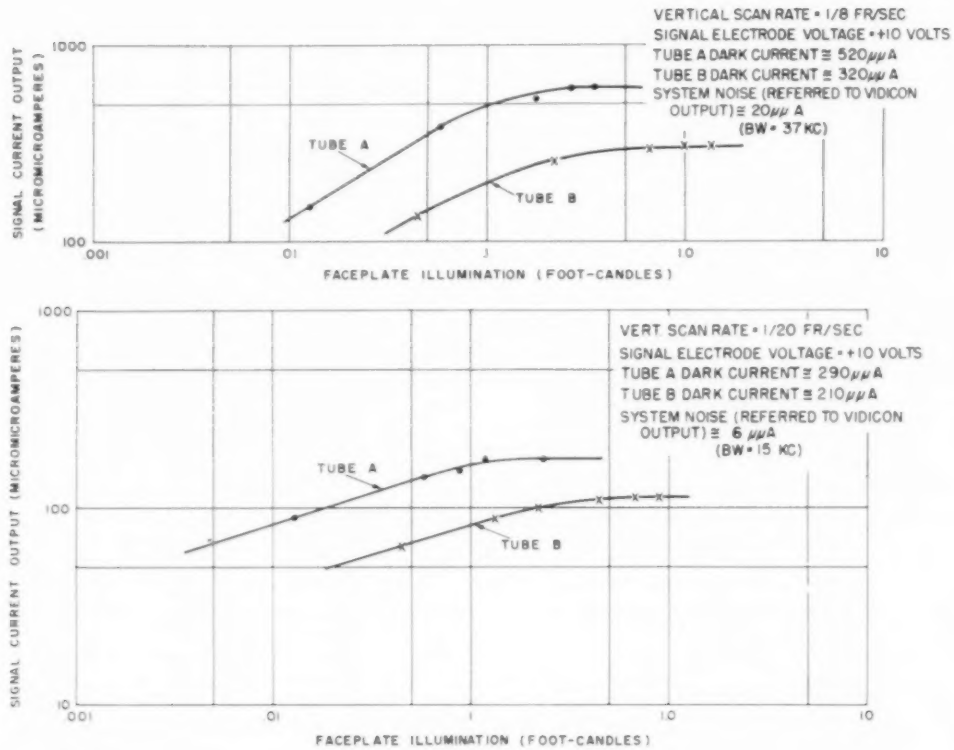
At very slow rates, 30 sec or more per frame, another mode of operation is sometimes observed. Apparently the target has time to discharge between lines so that when the beam scans a given point the second time on the adjacent line there is no signal present. The tube, however, gives an image.

Any storage which takes place in this mode must occur during the time it takes the beam to pass a given point on the target. It may be that the signal current results from the resistive variation of the target rather than from charge variation. It is apparent that the sensitivity is quite low. Also the image quality is not good with this mode of operation. In normal vidicon operation the beam, as it lands, sees above and behind it areas which have just been charged to cathode potential.

occur. However, at reduced rates the target is pulled out of shape vertically. Therefore, while horizontal resolution is maintained, vertical resolution is very low.

dark current, we expect a greater than

brought to cathode potential on the first



Figs. 12A and 12B. Vidicon light transfer curves at $\frac{1}{8}$ and $\frac{1}{20}$ frame/sec.

Therefore, it is confined to that area which has not yet been charged. However, in the spot-sensitive mode of operation the area above it has had time to discharge to signal electrode potential. Therefore, while it sees a charged area behind it, there are high potential areas above, below, and in front of it. Since it is moving at very low velocity near the target it is easily deflected and in this case

(2) Vidicon Light Transfer Characteristics

The tests made used two typical samples of the 6326, referred to as tube A and tube B. Figures 11 and 12 indicate the variation of transfer characteristic with rate. Figure 13 indicates in a general way the variation of sensitivity with rate based on a signal-to-noise ratio of 10. The amplifier configuration used was not an optimum one from the standpoint of noise. A standard RCA TK30 camera amplifier was used instead of the low-noise cascode circuit which is common in vidicon cameras. The camera amplifier was modified very slightly; the value of each coupling capacitor was increased to improve the low-frequency response. Therefore, the absolute value of signal-to-noise ratio indicated in Fig. 13 could be improved, although the general shape of the curve should remain the same.

CONDITIONS OF OPERATION	10 FRAMES SEC	1 FRAME SEC	0125 FRAME SEC	0.05 FRAME SEC
SIGNAL ELECTRODE VOLTAGE	+50	+20	+10	+10
LOAD RESISTANCE (OHMS)	50,000	500,000	500,000	500,000
BANDWIDTH	3.2 MC	300 KC	37KC	15KC

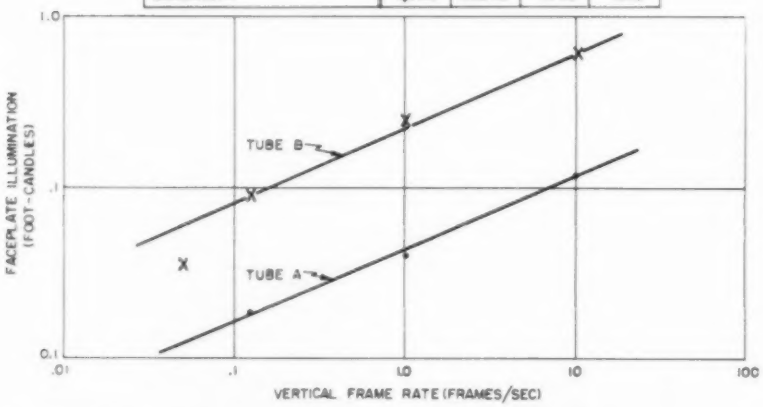


Fig. 13. Vidicon faceplate illumination for a signal-to-noise ratio of 10.

As discussed earlier, no consistent criterion was available for adjusting the target voltage at the various rates. It would not have been realistic to set the target voltage to a constant value for all rates since a single setting would have caused either excessive dark current at low rates or unnecessarily restricted sensitivity at high rates. The target voltage was therefore adjusted by observing the effects of dark current on the monitor image. Obviously such a procedure is rather subjective. Note especially the location of the data points for 0.05-frame/sec operation (Fig. 13). The remote location of these points from the trend lines probably was caused by the fact that the signal plate voltage of each vidicon was not reduced at 0.05 frame/sec from the value (+10 v) used at 0.125 frame/sec; whereas, it was found necessary to reduce

the voltage as the scanning rate was changed from 10 frames/sec down to 0.125 frame/sec. The trend line would have had a much steeper slope if it had been feasible to maintain a constant signal electrode voltage as scanning rate was changed.

The transfer characteristic for 10 and 1 frame/sec (Fig. 11), appear quite similar to those for standard rates except for the expected shift in signal output. At one cycle there is some tendency for the output to saturate at the higher light levels. Apparently the highlights are charging the target to a value near signal electrode potential.

Figure 12 indicates the limited dynamic range of the vidicon at low rates. The signal level, which is decreased because of low frame rate, is reduced still further because of the necessity of reducing the target voltage. Dark current discharge uses up a part of the useful dynamic range, so that there is little room left for signal. The action of dark current can be considered as a reduction of the useful signal electrode voltage. If, for example, it is assumed that the target can be permitted to swing four volts before encountering beam distortion, and the dark current alone discharges the target two volts, then the useful signal range has been halved. The effects of signal electrode voltage reduction and dark current discharge were not taken into account in the previous predictions of sensitivity change.

While good resolution was maintained at 20 sec/frame, the tube was beginning to operate in a rather marginal manner. This rate can be considered a practical limit for the tubes tested. It would require testing a large number of tubes to determine an average lower limit.

It should be pointed out that there is a lower limit on signal electrode voltage. Since the beam picks up some velocity component parallel to the target as it is deflected, it does not land with the same velocity in the corners of the target as in the center. As target voltage is reduced it reaches a value where the beam is unable to land in the corners and therefore there is no signal except in the center. This effect, known as porthole, limits the signal electrode to values above about 5 v.

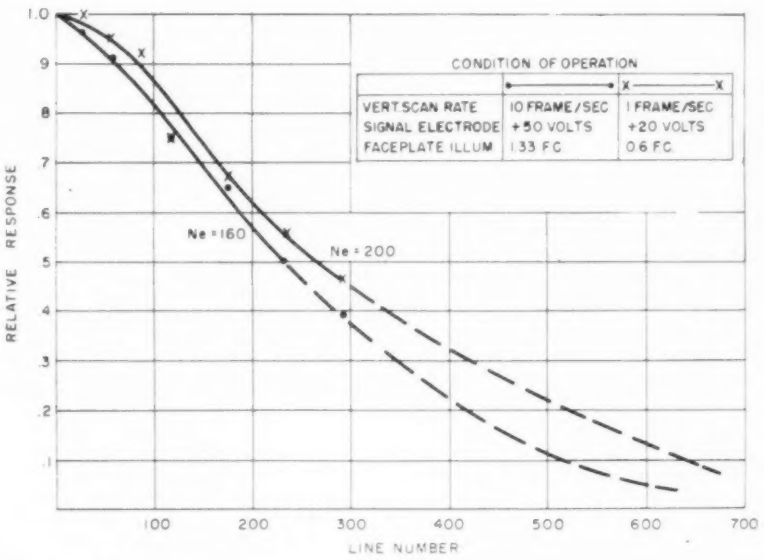


Fig. 14. Vidicon aperture response for Tube A.

(3) Vidicon Resolution

Aperture response curves, taken at 10 and 1 frames/sec, are shown in Fig. 14. At the two lower rates of $\frac{1}{8}$ and $\frac{1}{20}$ frame/sec checks at a few line numbers indicated approximately the same resolution as at 1 frame/sec. It is seen that the resolution goes up from about $N_e = 130$ at standard rates to $N_e = 160$ at 10 frames/sec and $N_e = 200$ at 1 frame/sec. These measurements were made with the tube operating in the frame sensitive mode. The increase in resolution with rate reduction is apparently brought about by the fact that the reduction in beam current results in a smaller spot size. The expected effect of lateral leakage of charge does not appear to be significant at the rates considered.

Conclusions

Slow-scan operation of pickup tubes has been shown to be feasible under certain conditions. As expected, greater sensitivity is achieved at reduced rates and with the vidicon some increase in resolution occurs. However, there is a lower limit on scanning rate, below which image quality deteriorates. Operation below this limit would require a modification of the internal characteristics of the tube.

Acknowledgments

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The authors would like to acknowledge the contributions of E. A. Boyd who designed and operated the slow-scan system and R. L. Schmid who assisted in the collection and preparation of data.

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New Directions in Aircraft Instrumentation

The thin cathode-ray tube and transparent screen described in the following papers may provide at least a partial answer to one of the most pressing problems involved in contemporary aircraft development — that of how to keep instrumentation abreast of advances in aircraft design. A pilot must instantaneously coordinate and evaluate many items of information. Within the limits of human capability, he must depend upon instrumentation. An examination of this problem indicated that some of the requirements could be met with a thin, transparent viewing window through which the pilot may observe the real world, or on which he may watch a representation of that world when weather or other conditions make direct viewing impossible. Such a device would also provide an answer to the problem of space limitations.

At first this was thought impossible, and a number of the approaches tried were found to be unworkable; but we fortunately learned about the development of the thin cathode-ray tube by Mr. Aiken and then, as Dr. Feldman will set forth, we were able to develop a transparent phosphor for the tube for our use. It may well establish a new direction in aircraft instrumentation — *George W. Hoover*, Commander, USN.*

Development of the Thin Cathode-Ray Tube

By WILLIAM ROSS AIKEN

The thin cathode-ray tube, invented by the author and developed by Kaiser Industries West Coast Electronics Laboratory, is described. Designed primarily for "on-the-wall," viewing, the thin tube has excellent focusing properties and permits simultaneous viewing from both sides of the display surface. The electron beam is injected along an edge of the tube and deflected twice to form a spot on the viewing surface. The physical configuration and sweeping circuits are described.

THE Kaiser-Aiken thin cathode-ray tube differs radically from conventional types in that the basic building blocks which comprise a cathode-ray tube (electron gun, accelerating and deflecting structures, and display screen) are here arrayed in a novel fashion. It is this departure from the usual "in-line" arrangement that makes the principal advantage of the thin tube, its reduced size, possible. The importance of reducing the tube dimension perpendicular to the viewing screen (usually called *length*, but here perhaps more appropriately called *thickness*) is self-evident in circumstances where space is at a premium, e.g., in aircraft instrument panels. The reduction in bulk is obviously an attractive feature in many other applications also, as in TV receivers.

In comparison with conventional types, the thin tube has several other inherent advantages, particularly the powerful deflection-focusing action which makes it possible to utilize larger beam currents for a given "spot size" or to obtain a smaller spot size with the same current with improved brightness and/or resolution. Moreover, by relatively simple modifications of the basic model, the thin tube can be adapted to provide such special features as transparency, viewing of both sides of the display screen, and two or three primary color displays. The tube can, of course, be adapted to perform all the multifarious tasks that certain special display tubes can do, such as displaying characters and serving as a memory (storage) element.

Based on an oral presentation October 7, 1957, at the Society's Convention at Philadelphia by Wm. Ross Aiken, Kaiser Aircraft and Electronics, Palo Alto, Calif. Another version of this paper, which includes a mathematical analysis of the focusing action, was published in the *IRE Proceedings* for December 1957.
(This paper was received on March 24, 1958.)

* The above opinions or conclusions are those of the author and are not to be construed as necessarily reflecting the views or possessing the endorsement of the Navy Department.

Principle of Operation

Only one of a large number of possible configurations will be described (Fig. 1). The electron beam is injected along the bottom edge of the display screen, and travels in a field-free region between a set of electrodes, called horizontal deflection plates, and the bottom edge of the screen. If this edge and the horizontal deflection plates are all at the same (gun anode) potential, the beam continues all the way to the right. If the voltage on one of the deflection plates is lowered, the beam is deflected upward. The position at which this deflection occurs can thus be moved in a continuous manner from right to left or from left to right by sequentially lowering the voltage on adjacent horizontal deflection plates in the proper direction.

The upward deflected beam enters another field-free region, bounded on one side by the phosphor screen and on the other by a set of strip electrodes (vertical deflection plates), each of which extends all the way across the tube. If the vertical deflection plates are all at the same potential as the phosphor, the beam continues all the way to the top, but if the voltage on one of the deflection plates is lowered, the beam is deflected into the phosphor. Again, the position at which the deflection occurs can be varied continuously by sequential variation of the voltage on adjacent deflection plates. By choosing the appropriate sequence for each of the two sets of deflection plates (horizontal and vertical), the spot at which the beam strikes the phosphor can thus be made to sweep out a raster.

For practical reasons, the region of the horizontal deflection plates (primary section) is usually isolated from the region between the vertical deflection plates and the display screen (secondary section) by a transition section. The transition section comprises additional electrostatic lenses, so that it not only isolates the primary section from the secondary, but provides additional means of controlling beam focusing as well. The main reason why a transition section is necessary is that the primary section is operated at potentials of the order of the accelerating (anode) potential of the electron gun, i.e., about 1 kv, whereas the secondary section is of necessity operated at the potential of the display screen, which with present-day phosphors must be about 15 kv.

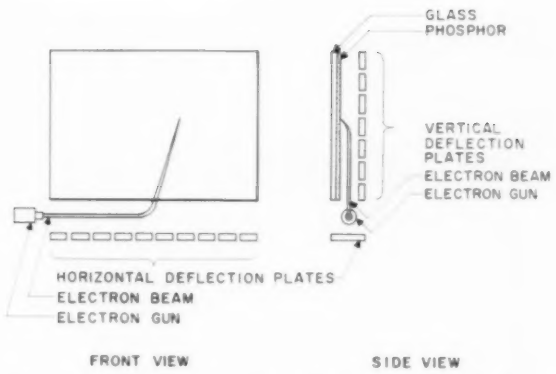

Fig. 1. Schematic diagram of operation of the thin cathode-ray tube.

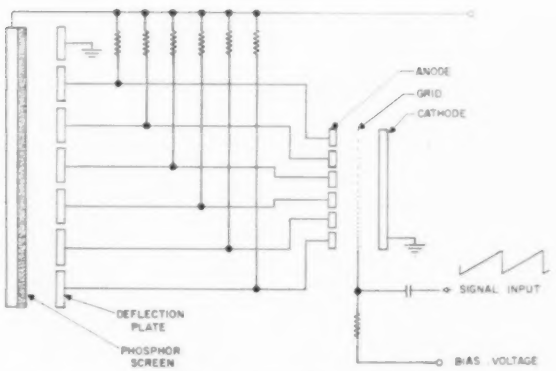

Fig. 2. Variable-mu voltage-sweep tube for secondary section

Under these circumstances, the bottom edge of the display screen cannot serve simultaneously as part of both the primary and secondary sections, and a transition section must be provided. An additional lens system is often made part of the transition section, to counteract the action of the effective convergent lens on the beam as it passes from the low-voltage primary to the high-voltage secondary section, and also to provide additional beam-focusing controls after the first deflection.

Deflection Focusing

When an electron beam of finite thickness is deflected by a uniform electrostatic field, the beam is also focused. In conventional tubes, so-called "deflection defocusing" results if the beam actually comes to a crossover as a result of this action and then diverges before arriving at the display screen. In the thin tube, deflection focusing is turned to advantage by judicious juxtaposition of the deflecting plates with regard to the beam and to the display screen.

Upon deflection by the horizontal deflection plates (primary section), the beam is brought to a focus in a plane parallel to the display screen and, if the transition section is properly designed, the cross section of the beam is changed from circular to elliptical as the beam enters the secondary section, with the major axis of the ellipse oriented normal to the display screen. The cylindrical beam traveling horizontally along the primary section thus becomes more or less a ribbon beam as it begins its upward travel.

Upon deflection by the vertical deflection plates (secondary section), the process is repeated, and the beam is again focused, this time in a vertical plane perpendicular to the display screen. The ribbon beam then becomes a pinpoint as it tends toward a crossover. If the display screen is located at a plane just before this doubly focused beam would actually come to the second crossover, a relatively small spot size at the display screen can be achieved.

The beam is not permitted to diverge after passing through the crossover toward which it tends as a result of the *first* deflection in the primary section and it may not even reach this crossover. The combined action of the transition section and of the effective lens through which the beam passes as it travels from the low-voltage primary to the high-voltage secondary section is to offset any tendency of the beam either to diverge or to converge. This action can be optimized in practice by transition-section design and by adjustment of voltages to correct for any adverse effects, including that of space-charge beam spreading.

In a conventional tube, the maximum beam current that can be focused to an acceptably small spot size (uniform over the entire display screen area) is determined mainly by the efficacy of the electron gun and focusing structure in offsetting space-charge spreading and in accommodating the electron-optical aberrations that result from the necessity for deflecting the beam through a large range of angles. It will be appreciated that in the thin tube, the design of the electron gun or the effect of beam blow-up are by no means the limiting factors in achieving small spot size. The deflection-focusing action can be used to such good effect that resolutions far in excess of those obtained in conventional tubes at comparable phosphor-voltage and brightness levels can be obtained without the expenditure of any special effort whatsoever on electron-gun design; in fact, in most of the models tested to date, standard commercially available cathode-ray tube guns have been used with excellent results.

Effect of the Exit Slot

In order to enable the deflected beam to leave the primary section, the low-voltage horizontal deflection plates, which in practice are shaped like rectangular channels in cross section, must face a slot in the direction of beam travel. This slot represents an important part of the transition section, and must be taken into consideration in the design of this section. One practical arrangement, for instance, is to provide an almost field-free region between the primary and secondary sections. In that event, the slot acts like the well-known Davisson-Calbick thin lens (divergent) and the beam actually diverges in the plane perpendicular to the long dimension of the slot; however, the divergence is offset by the action of the effective convergent lens represented by the passage from the low-voltage field-free region to the high-voltage secondary section.

In the plane of the slot parallel to the display screen, the beam converges as a result of the deflection-focusing action; it is unaffected by the slot, approaches a crossover, and would begin to diverge if it were not for the offsetting action due to the transit from low to high voltage. In the detailed electron-optical design of the transition section, factors such as space-charge spreading and the noncircular beam cross section resulting from astigmatic focusing must be taken into consideration.

It should again be emphasized that the excellent practical results obtained to date have not depended on the design of the electron gun; further improvements may well result from modifications which would serve to adapt the gun to the special application under consideration (such as providing a noncircular beam on entry to the primary section). But even with standard commercially available guns, the deflection-focusing action of the thin tube yields considerably greater definition without a sacrifice of brightness than can be attained with conventional tubes.

Sweep Voltage

Approximately 10 deflection plates are used to produce a commercial TV raster in both the primary and secondary sections. It is not necessary, as might appear at first glance, to provide, say, 525 deflection plates to produce a 525-line raster. Instead, the voltage on each deflection plate is varied monotonically

Fig. 3. Experimental TV receiver incorporating a thin tube.

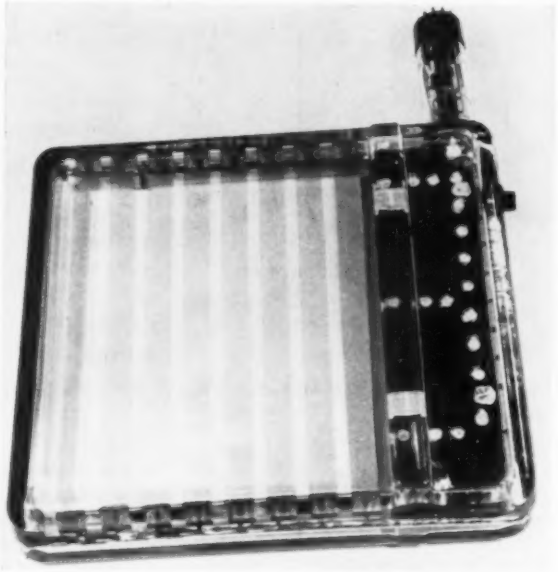

Fig. 4. Experimental sealed-off model (back view). The strips are the vertical deflection plates made from conducting material deposited on the inside of the glass envelope.

from full voltage to near zero, in such a way that as one plate approaches zero potential, the next one begins to decrease from its full value. It is expedient to allow the voltage waveforms to overlap in time, i.e., the voltage on the second plate is caused to begin decreasing considerably before the first plate has reached zero potential, with a resultant averaging of the deflecting forces acting on the beam. Various combinations of waveforms and amount of overlap can be used to obtain good linearity.

A number of possible schemes for achieving such sequential operation have been developed. Perhaps the simplest scheme consists of connecting the deflection plates to the anodes of a multi-anode triode provided with a single variable-mu grid wound in such a way that the several anodes are located opposite a progressively tighter grid mesh (Fig. 2). A positive-going sawtooth voltage applied to this grid will cause the tube to conduct progressively from top to bottom, so that the requisite sequential operation is obtained; the resistors serve to return the plates to their initial voltage during the retrace pulse. Alternately, a series of separate tubes can be used and the several tubes differently biased to require a progressively larger grid pulse to cause conduction. A sawtooth pulse is then applied to all the grids.

Fig. 5. "Windshield" model developed for integrated aircraft instrumentation.

In another scheme, a sweep tube comprising a cathode-ray gun in conjunction with a series of targets is used with each target connected to a deflection plate. Sequential operation is obtained by deflecting the beam so that it sweeps across the targets in sequence. Resistors are again used to return the several deflection plates to their initial voltage, except that here they can do so without waiting for the retrace.

Other arrangements involve tapped pulse lines, radial beam-switching tubes, and other special devices. It should be pointed out that any electronic device intended for voltage switching in the *secondary* section must be rated for operation at voltages up to 20 kv.

Practical Results

A number of models of the Kaiser-Aiken thin cathode-ray tube have been constructed, both the continuously pumped and sealed-off types. Figure 3 shows an experimental TV receiver that can be viewed simultaneously from both sides, through the use of transparent vertical deflection plates such as can be obtained by depositing strip layers of a transparent conducting material on the back plate of the glass vacuum envelope. The tube in this particular receiver is a sealed-off model that measures 12 by 12 in. (Fig. 4). The horizontal (primary) deflection section contains 10 deflection elements, each approximately an inch in length. The vertical (secondary) section consists of 8 plates, about one inch wide, made of conducting material deposited on the inside of the back surface. Primary and secondary operating voltages are approximately 1 and 12 kv, respectively.

Another version of the tube is shown in Fig. 5. In this form, the tube is used in conjunction with the Army-Navy Instrumentation Program (ANIP) (*Aviation Age*, p. 34, Oct. 21, 1957). A transparent phosphor is used in addition to the transparent conducting plates mentioned above, so that the tube is rendered entirely transparent and can be placed in the pilot's windshield without obscuring his vision when the tube is not in use.

In the laboratory, thin tubes up to 24 in. (diagonal) have been constructed, and resolutions as great as 2000 lines (at nearly acceptable brightness levels) have been achieved. In general, the substitution of an electrostatic for a magnetic deflection system makes it possible to achieve deflection with the expenditure of less power than in conventional tubes, especially if care is taken in selecting a deflection-control scheme by which a minimum number of deflection plates is maintained in a lowered-voltage condition at any instant. By this method, a minimum amount of power is wasted in those plate resistors which are not active in beam deflection at that instant. The deflection-focusing action proves to be relatively insensitive to quite substantial variations in the deflection voltages. The percentage changes in both deflection angle and final spot size, as the primary- and secondary-section voltages are varied, turn out to be very small compared with these voltage changes. Operation of the thin tube is therefore relatively insensitive to power-supply instabilities. Moreover, since the beam is deflected through the same two angles regardless of the ultimate spot position, no aberrations such as are inherent in the variable-angle deflection systems of conventional tubes are present, nor can the effects of other aberrations or fabrication errors become very prominent. Since the beam travels only a very short distance after the second deflection, there is vir-

tually no "lever arm" to magnify such distortions. There is neither pincushion nor barrel-type distortion.

One aberration present in these models arises from the finite value of the injection velocity in the initial direction of beam travel. The tangent of the angle with which the beam is deflected out of the primary section is equal to the ratio of horizontal velocity to vertical velocity, i.e., to the square root of the ratio of the corresponding voltages. Since the electrons must be injected with a finite (horizontal) velocity, the deflection angle is not quite a right angle, so that an uncorrected rectangular raster would appear as a parallelogram skewed at an angle that in practice falls around 80°. This aberration can be corrected by a number of methods, including positioning of the gun and transition section at the same angle with respect to the bottom edge of the display area; making a correction in the controlling signal; or immersing the primary section in a localized transverse magnetic field, such as can be obtained by means of a very simple magnetic circuit (a U-shaped bar pole piece) located outside the vacuum envelope.

Finally, methods of adapting the thin tube to two or three primary color operations have been worked out, and experimental models show very promising results, especially with regard to linearity and raster registration.

Acknowledgment

The author gratefully acknowledges the aid of Dr. Charles Susskind, University of California, in the preparation of the manuscript.

Discussion

Charles O. Probst (Cinefonics): Can you give us an indication of the amount of data displayed on the windshield panel, how many bits are put together and something of the nature of the information given to the pilot?

Mr. Aiken: I would like to, but this information is classified.

Stanley Dobren (Radio Corp. of America): Can you give an idea of the brightness with 400 lines/in. on the flat tube?

Mr. Aiken: I believe that was 40 or 50 ft-L.

Mr. Dobren: Was that a conventional phosphor or a transparent phosphor?

Mr. Aiken: That was not a conventional phosphor. The grain size of a conventional phosphor is far too large for that. We used special phosphors and also Dr. Feldman's phosphor on some of those tests.

Mr. Probst: [Apparently, some of this information was declassified subsequent to Mr. Aiken's paper. Pictures of the "contact analog" presentation on this transparent cathode-ray tube display can be found in *Aviation Week*, Dec. 30, 1957; also Apr. 28, 1958; and in *Aviation Age*, June 1958.]

Development and Applications of Transparent Cathode-Ray Screens

By CHARLES FELDMAN

The process of forming transparent luminescent screens by evaporation in a vacuum is described. The method is applicable to most of the common phosphors and yields screens having the same properties as these phosphors. Advantages of transparent screens, such as high resolution and high contrast, are discussed. Applications of the transparent screen to the Navy's flat cathode-ray tube, the daylight viewing tube and the laminated color tube are described.

THE POWDERED phosphor luminscent screens that are employed today in television and cathode-ray tubes are composed of layers of small luminescent grains whose diameters are between 3 to 8 μ. This grain structure causes the screens to be white and opaque. The luminescence produced in the screen by the electron beam is scattered laterally by the grains, limiting the resolution of the image. Ambient light falling on the screen is scattered back to the observer making the screen appear bright and thereby limiting the contrast of the image.

It is desirable, therefore, to form luminescent screens free of grains that scatter light. Such screens will be transparent, providing, of course, the crystalline material is transparent. One could, in principle, accomplish this by growing a single crystal of the phosphor having the dimensions of the TV or cathode screen desired. However, this is quite impossible with the present crystal-growing technique. One can, on the other hand, accomplish the same thing by forming the screen of grains which are too small to scatter light. To accomplish this the grains must be approximately 100 times smaller than those currently employed. The technique, described here, of thermal evaporation in a vacuum has proved to be singularly successful in producing luminescent screens of sufficiently small grain size to be transparent.[1] The luminescent screens formed by this method are thinner (0.1 to 1 μ) than the diameter of a single grain in the conventional powdered material. Figure 1

Fig. 1. The transparent cathode-ray screen.

Presented on October 7, 1957, at the Society's Convention at Philadelphia by Charles Feldman, Naval Research Laboratory, Washington, D. C. (This paper was received on May 8, 1958.)

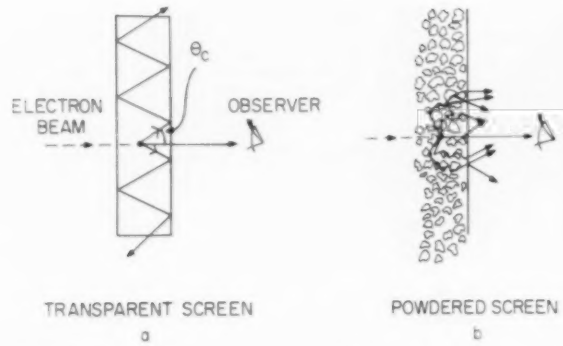

Fig. 2. Schematic diagram illustrating the difference between powdered screens and transparent screens.

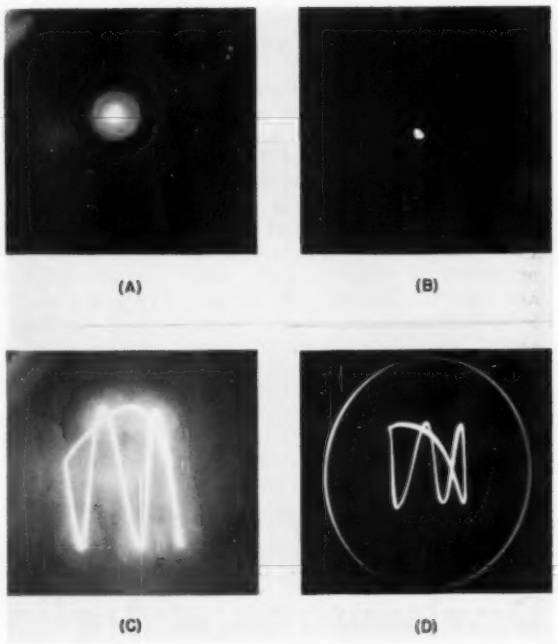

Fig. 3. Photograph of electron beam trace on a conventional powdered screen (A,C) and a transparent screen (B,D), illustrating the difference in definition between the two types of screens.

Table I. Light Loss by Internal Reflection.

Material	Index of refraction, n	Critical angle, θ_c	Amt. of light reaching observer
ZnS	2.4	25°	5%
$CaWO_4$	1.9	32°	8%
Zn_2SiO_4	1.7	36°	10%
CaF_2	1.4	46°	15%

illustrates the transparent nature of these screens.

The image on conventional powdered screens will be brighter than the image on the corresponding transparent screen. In the powdered screens the light from the image is scattered to the halo and central spot (Fig. 2), while in the transparent screen a large fraction of the luminescent light is trapped by internal reflection and escapes only at the edges of the screen. Figure 3 is a photograph of the electron images produced on a conventional screen and a transparent screen. The fraction of total light reaching the observer from a completely transparent screen may be easily estimated.

Assuming a nonabsorbing film, the ratio of the light emitted from the face of the screen in the direction of the viewer to the total light output is:

$$\frac{\text{solid angle subtended by the angle of internal reflection}}{\text{total solid angle}} = \frac{(1-\text{Cos}\theta_c)}{2}$$

where θ_c is the critical angle of internal reflection defined by:

$$\text{Sine } \theta_c = 1/n$$

where n = refractive index of luminescent layer.

The critical angles and percent of light reaching the observer for a few common phosphors are listed in Table I.* Referring to this table, it can be seen that twice as much light reaches the observer from a Zn_2SiO_4 screen as from a ZnS screen. This implies that even though the ZnS screens are more efficient than the Zn_2SiO_4 screens in the powdered form, they may have equal efficiency in the transparent form.

These figures represent the minimum amount of light reaching the observer. Any absorption, imperfection or nonuniformity of screen thickness, or slight fogging of the film will increase this value. Measurements by Studer and Cusano[2] and the author[1] indicate that in actual practice no more than 50% of the light is lost by this mechanism. By aluminizing the transparent screens the brightness may be approximately doubled. However, contrast and transparency are lost at the same time.

The light loss due to internal reflection may be easily recovered by operating the cathode-ray tubes at higher power levels. Due to the greater adhesion of the transparent films to the glass substrate and due to the thinness of the films, the heat generated in the phosphor by the electron beam is dissipated rapidly. The electron beam power may consequently be raised by at least a factor of 2 to 3 without danger of producing screen burn.

* The critical angle for the luminescent screens is uninfluenced by the substrate, additional superimposed layers or the side from which the screen is viewed. (There would be, of course, a negligible difference depending on whether one or both sides of the screen is surrounded by vacuum.) This can be seen by calculating the critical angle on the glass side of a screen:

Consider a luminescent film of refractive index n, on a glass substrate of refractive index n_g, surrounded by vacuum (or air) of refractive index $n_0 = 1$. Light is produced at a point in the luminescent film and enters the glass substrate following the usual relation:

$$\frac{\text{Sine i}}{\text{Sine r}} = \frac{n_g}{n}$$

where: i = angle of incidence of a beam entering the glass

r = angle of refraction in glass.

The beam of light then goes from the glass to the vacuum according to:

$$\frac{\text{Sine } i_1}{\text{Sine } r_1} = \frac{n_0}{n_g} = \frac{1}{n_g}$$

where: i_1 = angle of incidence of beam going from glass to air

r_1 = beam angle emerging into the vacuum (going to viewer).

Making use of the fact that the layers are parallel and therefore $< r = < i_1$, and eliminating n_g from the above two equations one obtains:

$$\frac{\text{Sine } r_1}{\text{Sine } i} = n$$

or when $r_1 = 90°$, $i = \theta_c$

$$\text{Sine } \theta_c = 1/n$$

Thus, the critical angle of the entire screen is determined only by the refractive index of the luminescent film. This argument may be repeated for any number of layers.

Formation of Transparent Luminescent Screens

The formation of the transparent screens involves essentially two distinct steps. The first step is the evaporation of the commercial phosphor material onto a glass substrate. During this evaporation the phosphor decomposes into its more stable molecular components and condenses on the substrate as a film composed of a mixture of these components. Zn_2SiO_4[Mn], for example, decomposes into reduced ZnO, SiO_2 or SiO, and MnO. Some phosphors such as ZnS[Mn] decompose only into ZnS and MnS. The second step then involves the recomposition of these components into the crystalline phosphor on the substrate. This step is accomplished by firing the layer in the proper atmosphere.

The evaporation is performed from the best obtainable commercial phosphors in a vacuum bell jar system under a pressure of about 5×10^{-5} mm Hg. The size of the screen is thus limited only by the dimensions of the vacuum chamber. The usual procedures for forming films by evaporation are applicable to phosphor films. However, the requirements for purity are more stringent than in other types of evaporations and therefore precautions must be taken to eliminate all sources of impurities. The substrates are cleaned and outgassed thoroughly. A removable screen is kept between the filament and substrates until the material in the filament begins to evaporate. A liquid air trap is used to prevent oil from the diffusion pump entering the system.

Table II summarizes the details of the procedures used in forming the screens. The last column of this table lists the firing conditions used in forming the luminescent screens. The freshly evaporated films generally exhibit little or no luminescence. However, when the films are fired in a proper atmosphere good luminescence results. The activator impurity, essential to luminescence, is not lost in the evaporation process, as is generally assumed, but is incorporated in the film as a separate phase. Firing the film causes the activator to diffuse into the host crystallites of the film and at the same time causes good crystallite formation. In the case of the phosphors containing oxygen, $CaWO_4$, Zn_2SiO_4 and $Zn_3(PO_4)_2$, etc., the firing also serves to oxidize or add oxygen to the partially reduced compounds. When these phosphors are evaporated some of the oxygen is lost and the resulting films are dark in color. The dark color disappears at relatively low temperatures ($\sim$300 C) but no luminescence results at these temperatures.

The best firing temperature for forming the luminescent films appears to be about the same as that used in forming the powdered phosphor material. If the films are overfired (at either too high a temperature or for too long), the crystallites grow rather large and the screen becomes fogged. It has been found that the usual phosphor chemistry is generally applicable to thin films. For example, the condition for forming the various crystal phases found in the bulk powder appear to be the same in the films. An illustration of this is in the formation of the α and β phases of $Zn_2(PO_4)_2$. Likewise, the amount of activator in the film necessary for maximum luminescent efficiency appears to be about the same as in the luminescent powdered material.

Due to the high (500 C to 1100 C) firing temperatures necessary, the choice of glass substrate material is quite important. In addition to being able to withstand high temperatures, it has been found desirable in some cases to have the thermal expansion coefficients of the film and substrate similar. This matching of expansion coefficients helps to prevent very thick films from cracking as they are fired. In the case of ZnS film, a glass meeting these requirements was made at the National Bureau of Standards. (This substrate is designated in Table I by "N.B.S. special glass.")

The relationship between phosphor and glass substrate is further complicated by the diffusion of impurities from the glass into the film as it is fired and by the possible chemical reactions that can occur between glass and phosphor at the high temperatures used. These phenomena are currently being studied.

The luminescent screens formed in this manner on the proper substrates are extremely rugged and the adherence to the glass is excellent. These screens may be cleaned and polished without fear of destruction. This is quite a contrast to the delicate nature of the settled powder screens. The luminescent properties of the screens, with the exception of a loss of brightness, already described, of about 50%, are identical to the conventional powdered screens. The luminescent emission peaks correspond to those observed in the powdered material. The voltage and current relationship conform with the general phosphor theory.

It has been found essential to place a conductive layer on top of the luminescent film in order to prevent charges from building up on the surface. This charging of the screen surface by the electrons appears to be greater in the evaporated screens than in the powdered-type screens. Thin conducting layers of stannic oxide, cuprous iodide and aluminum have been used for this purpose. The aluminum layer is used only when nontransparent screens are desired. All of these layers may easily be deposited on the screen surface. The high firing temperature used in forming the luminescent screens on the substrates made it impractical to deposit the luminescent screen on glass already coated with a conducting layer.

Table II. Conditions Used in Forming Luminescent Films.

Phosphor material	Filament	Filament temp. (approx.)	Duration of evaporation	Substrate	Firing conditions: Atmosphere	Firing conditions: Temperature
ZnS [Mn]	Tantalum boat	1050 C	1 hr	N.B.S. Special glass	Vacuum	750–800 C for 5–15 min
CaF_2 [Mn]	Tantalum boat	1550 C	5 min	Silica Glass	Vacuum	600–700 C for 5 min
(Zn, Mg)F_2[Mn] (P-12)	Tantalum boat	1500 C	5 min	Glass	Vacuum	600 C for 5 min
$Zn_3(PO_4)_2$ [Mn] (P-22)	Tungsten basket	1525 C	20 min	Glass	Air	850 C for 10 min
$CaWO_4$ [W] (P-5)	Tungsten straight wire	2000 C	3 min	Glass	Air	550 C for 2 hr
Zn_2SiO_4 [Mn] (P-1)	Tantalum boat	1300 C	30 min	Silica Vycor	Air	1100 C for 15 min
$MgSiO_3$ [Mn] (P-13)	Tantalum boat	1350 C	15 min	Vycor Silica	Air	1100 C for 15 min
(Ca, Mg)$(SiO_3)_2$ [Ti]	Tungsten basket	2000 C	5 min	Vycor	Air	950 C for 15 min

Applications

The transparent screens described here may generally be used to advantage wherever the conventional screens are used. The absence of scattering and gain in resolution (Fig. 3) brings about a great improvement in systems where resolution is important, as in computer read-out and flying-spot scanning. There are a number of applications, however, which require the use of transparent screens and which would be impossible with the present opaque powdered screens. Three of these applications, transparent flat tubes, daylight viewing

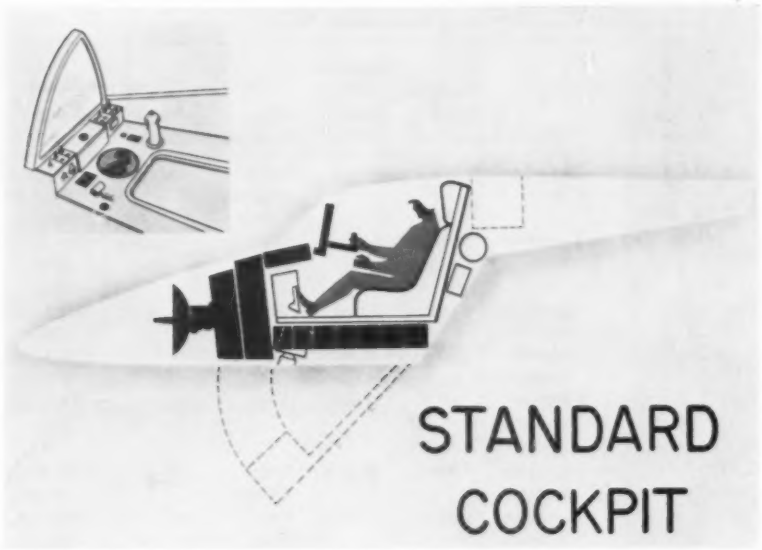

Fig. 4. Mounting of a thin transparent tube in a cockpit.

tubes, and laminated color tubes are described below.

(1) The Navy Transparent Flat Cathode-Ray Tube

The Office of Naval Research has for many years been conducting a long-range program of making basic improvements in aircraft instrumentation. This program is being carried out in conjunction with the Army and is known as the Army-Navy Instrumentation Program (ANIP). The goal of this work is to simplify the operation of jet fighter planes, to reduce the training time of pilots, and to help them get the maximum performance from their planes. As part of this program it was extremely important to obtain transparent luminescent screens for use in conjunction with the Aiken[3] flat cathode-ray tube. The tube is mounted just inside the windshield of the cockpit. The pilot then gets visual and electronic information at the same time and in the same position. Figure 4 illustrates a typical mounting of the flat tube in a standard cockpit. A Zn_2SiO_4 transparent screen used in the windshield tube is shown under test conditions in Fig. 5. Due to the large size of the screen it had to be sealed to the demountable cathode-ray tube by a rubber gasket in the manner shown in the photograph. The cathode-ray traces (horizontal lines) may be seen in the photograph.

These windshield-size transparent screens have been inserted inside the Aiken tube and are being tested in aircraft. The transparent screens are used as inserts because the Vycor plates on which they were formed are not compatible with the soft glass used in the tube. This problem of glass compatibility is currently being studied.

(2) The Daylight Viewing Tube

An important application of the transparent screen both in military and commercial fields is the daylight viewing tube.

In the powdered screens, as mentioned earlier, the ambient light is scattered back to the observer. As the brightness of the surrounding light increases, a point is soon reached where the image on the tube is no longer visible. For TV sets, this brightness level occurs under daylight conditions. For normal radar scopes this level is considerably lower.

If, on the other hand, the light falling on the tube face passes through a transparent screen into the tube where it is trapped, the tube face would appear dark regardless of the intensity of the light. The trace on the tube need not be ex-

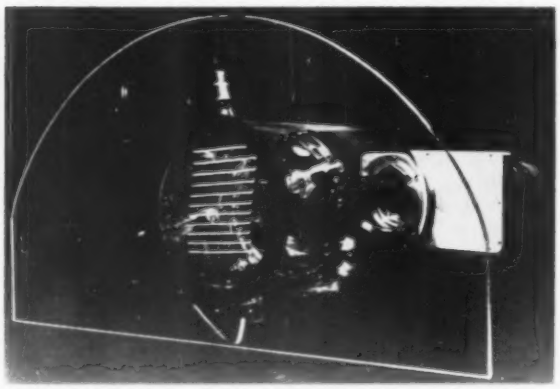

Fig. 5. Testing large windshield type transparent luminescent screen. The electron beam traces show as horizontal lines in the center of the screen. The light around the edges of the screen is due to interval reflection.

Fig. 6. Daylight Viewing Tube mounted in a simulated cockpit and illuminated with a 3-ft searchlight. Note black background on the tube face. The electron image on the tube consists of two concentric circles and a straight line.

tremely bright since the contrast remains good. This phenomenon is easily observed by looking down a long tube or pipe which is closed on the opposite end. The inside of the tube looks black regardless of the lighting conditions. Since cathode-ray tubes and pipes do not have the same geometry, one must cause the light to be absorbed by other means such as coating the inside walls of the cathode-ray tube or the back of the transparent screen itself with a light-absorbing medium such as carbon black.

Figure 6 shows a military application of this principle. A tube containing a Zn_2SiO_4 transparent screen, coated on the inside with colloidal carbon, was mounted in a simulated cockpit. A 3-ft searchlight was focused on the tube. The cathode-ray trace could be easily seen although the brightness of the trace was only about 40 ft-L and the brightness of the searchlight reflected from white paper was about 10,000 ft-L. This same principle applied to television proved to be equally successful.

(3) The Laminated Color Tube

The thin, transparent phosphor layers described above make possible a color television or cathode-ray tube system that has been contemplated for some time.[4] This system uses a screen consisting of layers of different phosphors deposited on top of one another.

The general principle of this laminated screen is shown in Fig. 7. Electrons enter the screen and strike Phosphor No. 1, exciting it to luminescence. This luminescence is viewed through the remaining phosphors and glass substrate. If the electron energy is low and the electron is stopped in this first layer, then the color viewed will be only that due to Phosphor No. 1. As the electron energy is increased, the electrons will begin to penetrate Phosphor No. 1 and excite Phosphor No. 2 which luminesces a different color than Phosphor No. 1. The color seen by the observer will be a combination of these two colors. At still higher energies the electrons will pass through Phosphor No. 1 without exciting it and the color viewed will be only that of Phosphor No. 2. One can continue this argument for three or more layers.

The electron energies or voltages at which the above events occur depend only on the thickness of the layers. By choosing the correct combination of phosphor layer thickness and nonluminescent spacers between these layers, the pure color of each phosphor may be obtained. For color television, a luminescent layer of each of the three primary colors is required. For other uses, such as radar, two layers may be sufficient.

Figure 8 shows the emission at different voltages from a two-layered screen consisting of:

$$\underset{\text{blue}}{CaWO_4[W]} \Big/ \underset{\text{yellow}}{ZnS\ (Mn)} \Big/ \text{glass}$$

The corresponding colors of each of these voltages is shown on the chromaticity diagram in Fig. 9. In this illustration the transition from blue to yellow required a voltage change of 15 kv. (Actually the color change from 8 to 16 kv appears to the eye to be about the same as the change from 5 to 20 kv.)

Other bilayer phosphor screens such as:

$$\underset{\text{red}}{Mg_2SiO_4} \Big/ \underset{\text{green}}{Zn_2SiO_4} \Big/ \text{glass}$$

have been examined (dotted line in Fig. 9). The red layer in this particular screen was sufficiently thin so that the transition from red to green passing through yellow and orange required a voltage change of only approximately 4 kv. Tricolor screens consisting of more complex layers have been made with equal success. Transparent laminated color screens have the same advantages of contrast and resolution as the single layer monochrome screens.

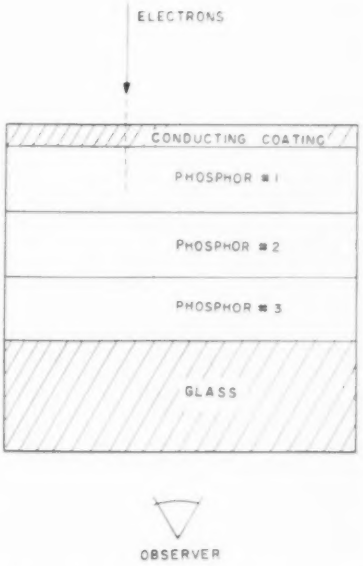

Fig. 7. Schematic of a laminated color screen.

Conclusion

The transparent luminescent screens described in this report are only in their early stage of development. Work on many other phosphors, on the reactions between glass substrate and phosphor and between phosphor layers themselves, plus a multitude of other details is still to be done, but there is no doubt of the importance of these screens to future developments in the television and cathode-ray tube industry.

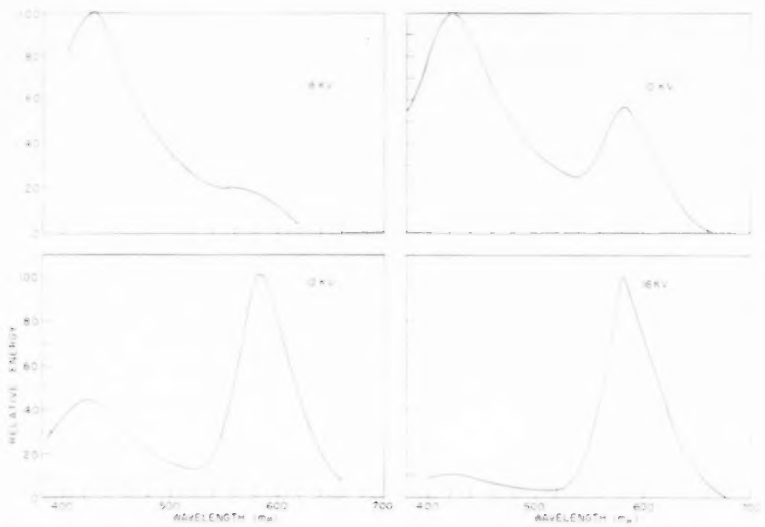

Fig. 8. Luminescent emission of a bilayer screen at various electron accelerating voltages.

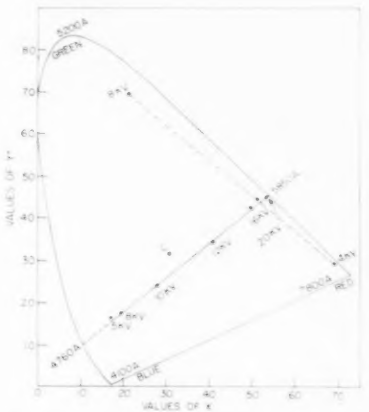

Fig. 9. Chromaticity diagram indicating the resulting colors from two different laminated color screens.

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2. F. J. Studer and D. A. Cusano, "Transparent phosphor coatings," *J. Opt. Soc. Am., 45:* 493–497, July 1955.
3. W. R. Aiken, "A thin cathode-ray tube," *Proc. IRE, 45:* 1599–1604, Dec. 1957.
4. Charles Feldman, "Bilayer bichromatic cathode screen," *J. Opt. Soc. Am., 47:* 700–704, Sept. 1957 (see also references cited).

Discussion

F. A. Toby Green (International Civil Aviation Organization, Montreal): You mentioned a system of air traffic control which employs a presentation of two different colors presumably for ground clutter and aircraft return. Would you discuss this further? Where is that system in operation?

Dr. Feldman: This is a simulated system at the Naval Research Laboratory that is to be tested in the field. Actually the display that I had in mind was the landing of aircraft on carriers. The planes were all displayed in green except the plane about to land which was in red. The real test of the system was in the switching mechanism which was used to switch from red to green. This was quite simple, because the switching could be done quite slowly.

Mr. Green: This will have application, then, to all radar traffic control?

Dr. Feldman: Yes, I should think so.

T. G. Veal (Eastman Kodak Co.): Is the decay characteristic materially different on these thin phosphors than for the conventional phosphors?

Dr. Feldman: No, due to the fact that we make the phosphors in exactly the same way as the conventional phosphors, the decay characteristics are the same. We have noticed some differences caused by substrate interactions, but in principle, we can reproduce exactly the same decay, as well as emission spectra, from these phosphors as in the bulk of the material.

Mr. Veal: Does the spectral characteristic of these phosphors behave similarly to the conventional phosphors? That is, does the decay characteristic produce long tails as you go toward the green and red end of the spectrum?

Dr. Feldman: Since the red is a longer persistent phosphor than the green, in the bilayer screen an observer sees a red tail.

L. M. Seeberger (Radio Corp. of America): What is the largest screen you have made so far with the transparent phosphor?

Dr. Feldman: The largest screen we've made is for the aircraft windshield program and is about 19 by 10 in.

Mr. Seeberger: Is there any particular problem of uniformity on these large screens?

Dr. Feldman: No, as a matter of fact, due to the vacuum process involved, screens can be made considerably more uniform than the conventional powdered ones.

George Lewin (Army Pictorial Center): Are these phosphors primarily for oscillographic images or can they reproduce tones for a TV picture?

Dr. Feldman: The phosphors are exactly the same as those used in TV. The reason we are showing red, green and blue screens, is that they are applicable for color television.

Mr. Lewin: Then it should have definite application as a television tube, as well as radar?

Dr. Feldman: Yes, definitely.

C. R. Daily (Paramount Pictures Corp.): The property of these new types of tubes which permits the presentation of pictures under high ambient light conditions, such as daylight, suggests a possible long-range application to drive-in theaters.

Dr. Feldman: Do you mean that essentially you want to present pictures by way of a television medium?

Dr. Daily: Yes, if the quality were good enough for the daylight drive-in theater.

Dr. Feldman: Perhaps there are other ways of doing this, using the same principle, that is, a transparent screen, but not cathode-ray tubes.

Anon.: It seems that what is needed is a transparent motion-picture screen with a black background, with the projection from the back.

Dr. Feldman: Yes. Of course, the optics of such a system requires considerable thought.

Dr. Daily: At the present time we are seriously handicapped by not getting enough total light to the screen, if the screen is very large. Here you are supplying energy per element and it changes the picture completely because you have retention from the phosphor. This might have a multiplying factor of effectiveness.

Dr. Feldman: Sounds like a good possibility.

Howard Rosenthal (Radio Corp. of America): In your slide you showed a conducting coating on the back of these films; could you tell us what kind of a coating this is?

Dr. Feldman: It is a conducting layer of tin oxide, or aluminum that is placed on top of the film.

Mr. Rosenthal: Then this additional baking does not destroy the phosphors?

Dr. Feldman: No, our phosphors are stable up to the temperatures at which they were baked originally.

Austin E. Hardy (Radio Corp. of America): What would you guess is the highest ambient light level in a cockpit that you would have to contend with?

Dr. Feldman: It is difficult to find the answer to this question. The only figure I can think of is 5000 ft-L for a bright cloud.

Mr. Hardy: If you have a level of 5000 to 10,000 ft-L on other parts of the interior of the cockpit, isn't there still great difficulty in reading information which is presented at a level of only 50 ft-L?

Dr. Feldman: This, of course, needs to be studied. The searchlight which was focused on the tube had a broad beam sufficient to encompass the whole cockpit; and the radar trace was visible. It is probably best to make the entire cockpit black.

Harry Pinch (Radio Corp. of America): When you have a bilayer phosphor, isn't there a chance of self-diffusion? For example, if the zinc silicate has to be fired at 1100 C and the calcium silicate at 1100 C, you are firing a two-silicate layer, zinc and calcium. Wouldn't one cross-diffuse and get a mixed crystal with a completely intermediate range of colors that you don't want?

Dr. Feldman: Yes, that is a danger. We often encounter mixing of phosphors due to diffusion. Careful baking, however, limits the diffusion to an extent where it becomes unimportant. We can limit self-diffusion by placing a nonluminescent layer between the two.

Mr. Pinch: But diffusion is a time problem.

Dr. Feldman: Diffusion is a time and temperature problem. You notice we fired our films for only 10 or 15 minutes — if we fired longer, diffusion would be more of a problem.

Bernhard A. Bang (Bendix Aviation Corp., Friez Instrument Div.): One of the problems with x-ray screens is that you cannot build the phosphor up to too great thickness or it will start reabsorbing the light. Is it possible to use your screen and build up the thickness and still further increase the light output?

Dr. Feldman: I think in principle it's possible, but in practice it would be difficult, because one needs a very thick film for an x-ray screen. Our films are very thin.

Television for Parade Control and Field Exercises

By HOLLIS DAKIN, FREDERICK L. MARTIN, PAUL A. J. BUE and JACK R. SMITH

Two successful applications of closed-circuit TV to military purposes are described. Control of the 1957 Inaugural Parade was facilitated by information supplied to the Parade Marshal from TV cameras placed along the line of march. During Operation King Cole at Fort Polk, La., the staff sections received the briefings over closed-circuit TV while they remained in their own offices.

PRESENT-DAY military applications of closed-circuit TV include many activities other than those directly concerned with combat superiority over a real or potential enemy. Closed-circuit TV is becoming increasingly useful in these applications because of technical developments and equipment designed especially for military use.

A noncombat military TV application was that of providing the Parade Marshal of the 1957 Presidential Inaugural Parade with means of control. The route of the parade in Washington has been covered by television before, but the 1957 parade had coverage from new angles and for a new purpose. The request for this military television service came from the Headquarters of the Military District of Washington, and the task was assigned to Field Units 4 and 5 of the Television Division, Army Pictorial Center.

Presented as two papers on October 7, 1957, at the Society's Convention at Philadelphia by Lt. Col. Hollis Dakin, Army Pictorial Center, 35-11 35th Ave., Long Island City 1, N.Y. This paper is a condensation of the two Convention papers, the first of which was coauthored by Lt. Frederick L. Martin and Lt. Paul A. J. Bue; and the second by Lt. Jack R. Smith.
(These papers were received on Sept. 24, 1957.)

Field Unit 4 is a mobile TV unit which has three ITV-6 camera chains, both UHF and microwave transmitting and receiving equipment, and equipment to receive airborne TV transmission. It also has control, switching and display facilities.

Field Unit 5, at that time, had three portable vidicon camera and transmitter systems, called Tele-Scout. Figure 1 shows one of the military cameramen with this equipment, standing on the roof of the Treasury Building. The turn from Pennsylvania Avenue into 15th Street appears in the foreground and the avenue stretches east toward the Capitol Building in the distance.

Commercial cable facilities were already allocated to other users and putting in special cables was out of the question, so the solution was to put in microwave links for all but those camera sites which might be close to the control site. The surveys of the parade route soon established six camera sites, the receiver site, and the location of the monitors. Microwave shots were made from all camera sites except the two on the Treasury Building. These were cabled directly to the video control point, which was also in the Treasury Building.

Fig. 1. Cameraman with Tele-Scout looking up Pennsylvania Avenue from the roof of the Treasury Building.

The rooftop sites were (1) the House Wing of the Capitol, (2) Federal Trades Commission Building, (3) The Post Office Building, (4) and (5) The Treasury Building, and (6) The U.S. Information Agency Building. Tele-Scouts were used on the Capitol, Information Agency Building, and one corner of the roof of the Treasury Building. The ITV-6 chains were used at the other sites. Figure 2 shows the camera posts and circuitry of the operation.

An AG-1 airborne TV camera chain was installed in an L-20 aircraft (Fig. 3). A signal was transmitted at 360 mc to a Yagi antenna on the roof of the Treasury Building, and from there it was cabled

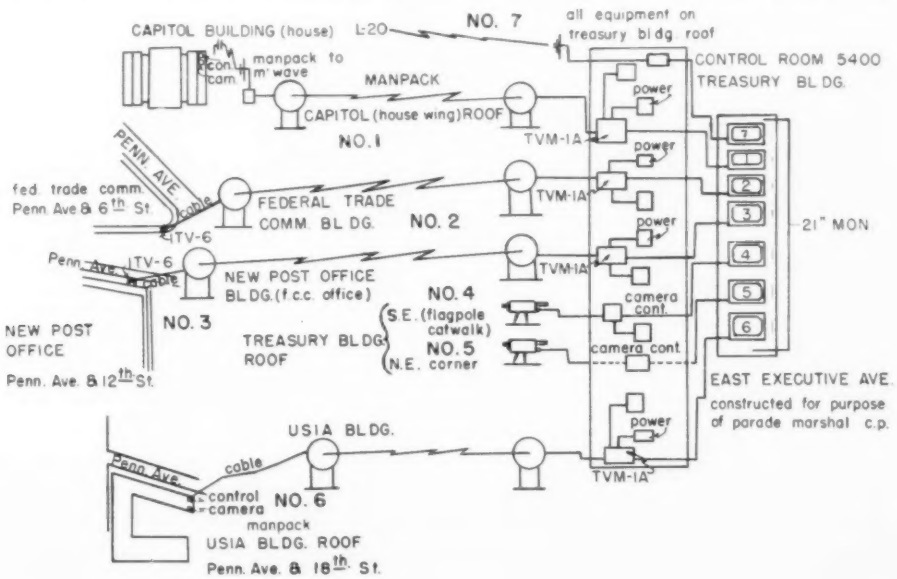

Fig. 2. Circuitry connecting camera posts with control location in Treasury Building; Cameras 1 to 6 on rooftops of Federal buildings and Camera 7 in an airplane overhead.

Fig. 3. AG-1 TV camera chain installed in L-20 aircraft.

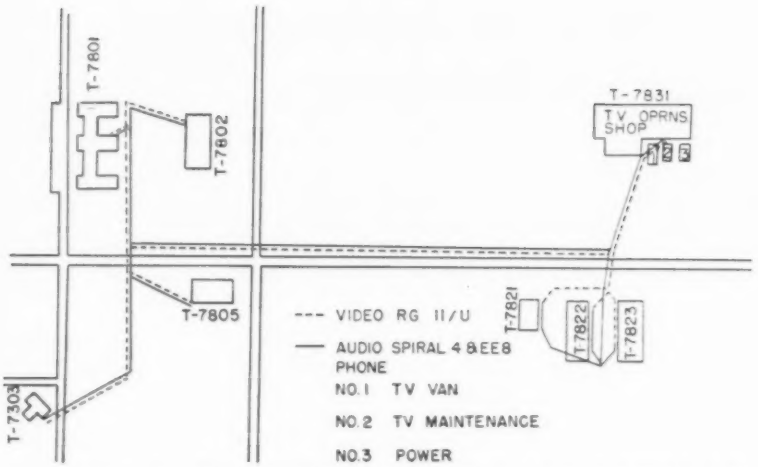

Fig. 4. Video and audio circuits of Studio Location Section. A total of 2300 ft of distribution circuits is involved. Broken line represents video RG 11/U. Straight line shows audio (Spiral-4) and telephone systems. Location of TV control, maintenance, and power vans shown as Nos. 1, 2 and 3.

Fig. 5. Operations Room, Operation King Cole, showing three cameras, Briefing Officer, and map. Note monitor for local check just behind camera platform.

Fig. 6. Group observing monitor in staff conference. Speaker above the monitor provides one-way audio from the control room.

down to the control room. At the Treasury Building, then, were the microwave receiving site, airborne video receiving location, radio net control for engineering circuits, and the video distribution point.

The Parade Marshal and his staff coordinated and controlled the parade from a tent headquarters near the Treasury Building. The video signals from the control site came into the tent over coaxial cable and were displayed on 21-in. monitors. The cable run was approximately 1200 ft, but sufficient video signal was available so that no line amplifiers were needed. On the day of the parade, all equipment was in continuous use from 8:00 A.M. to 5:30 P.M. Although telephoto lenses were tried, it was found that 25mm to 90mm lenses were preferable.

This project was selected as a typical example of noncombat military use of closed-circuit TV. Aside from the obvious advantage of enabling the Parade Marshal to keep the parade line constantly in view, this system assisted him to maintain the dignity of the occasion by reducing awkward incidents which might mar it.

Operation King Cole

Presentation of staff briefings over television during Operation King Cole has been selected as an example of the use of closed-circuit TV in military exercises. Operation King Cole was held at Fort Polk, La., during the Spring of 1957. Conducting the headquarters staff meetings over closed-circuit TV made it possible for the participating staff officers to remain in their own sections during the conferences, instead of having to be summoned to group meetings in the operations room. A major purpose of such meetings is to present visual in-

formation such as current situation maps, chart tabulations and operation maps of future actions, all of which can be presented effectively on TV.

In carrying out this project, the Television Division of the Army Pictorial Center supplied a Studio Location Section which consisted of 3 Du Mont image orthicon cameras, lighting equipment, audio facilities and a portable power plant. The layout of the distribution system is shown in Fig. 4. A total of 2300 ft of video and audio distribution circuits was involved. Two of the cameras were mounted on a 9 by 5-ft wooden platform at a height of 4 ft from the floor and 22 ft in front of the operations map. The third camera was placed on a balcony along the right wall of the room in which the briefings were given. It was 14 ft above the floor and 35 ft from the map. Four 1000-w scoops, two 2000-w spots, and four 1500-w scoops, hung from two suspended pipes above the operations map, furnished lighting (Fig. 5).

The lenses most frequently used on the center two cameras were 90mm and 135mm for cover shots and $8\frac{1}{2}$-in. and 12-in. for close-ups on the briefing officers and on the maps and charts. The camera on the balcony used a 35mm lens for general shots into the operations room and for title cards which were mounted on an easel directly in front of it and used a 20-in. lens for close-ups.

The control van was parked adjacent to the operations room with cables and lines dropped from overhead. Seventeen monitors were installed during the exercises (Fig. 6). Speakers above the monitors provided one-way audio from the operations room. Questions and requests for repeats or additional maps or charts were transmitted to the operations room over the telephone system provided by the Exercise Signal Officer. An example of chart information is shown in Fig. 7.

Following is a typical briefing schedule:

0645 Map of area

0655 Charts showing CP locations, nuclear blast explosions, and areas of chemical contamination by map coordinate.

0700 Weather briefing officer. Nuclear fallout patterns shown, also chemically contaminated areas and weather forecast.

0706 G-2 briefing officer. Enemy tactical situation shown. This portion of the briefing included POW information, pictures of captured enemy equipment, psychological-warfare leaflets and a tape recording of an intercepted enemy broadcast.

0710 G-3 briefing officer. Changes in friendly troop locations shown, also details of action which had occurred during previous broadcast.

0715 G-3 Air briefing officer. Chart shown of air activity and statistics.

The success of this TV operation suggests the extension of its use to communications between and among various headquarters, beyond some use reported earlier.* This has not been feasible so far because of the difficulty of transporting complex equipment under field conditions, and also because of transmission security considerations. It may well be, however, that new equipment and techniques will make the use of closed-circuit TV an accepted development of military science.

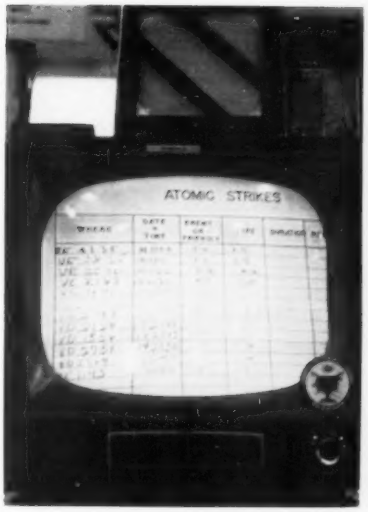

Fig. 7. Typical chart as seen by officers participating in conference.

* Norman Gray and James C. Jangarathis, "Television as a military intelligence and communication medium," *Jour. SMPTE*, 65: 415–418, Aug. 1956.

Technical and Production Problems in Military Television Recordings

By NORMAN GRAY

Problems encountered in making kinescope recordings for use in Army recruiting programs and for other purposes are described. Procedures differ from those followed in industrial establishments.

KINESCOPE RECORDINGS are used for various military purposes in preference to motion-picture photography because of such advantages as lower costs, reduction of editorial time, rapid availability of the finished product, economical recording of high-quality audio with video, ability to produce special effects electronically, and the availability of military trainees who frequently have worked in small TV stations and who make up in enthusiasm, initiative and imagination what they may lack in experience.

The main disadvantage of kinescopes is that their quality is inferior to that of motion pictures. Certain equipments and methods suitable for industrial purposes do not meet military requirements. This situation, however, may be regarded as temporary because of continuing developments.

Presented on April 30, 1957, at the Society's Convention at Washington, D.C., by Lt. Col. Norman Gray, Chief, Television Branch, Army Pictorial Service Division, Office of the Chief Signal Officer, The Pentagon, Washington 25, D.C.
(This paper was received on April 5, 1957.)

Methods Used in Military Recordings

Within the military, efforts have been made to bring the quality of kinescope recordings up to the highest standards. A chain, as we know, is only as strong as its weakest link. In producing kinescope recordings, there are many links in the chain where the quality of the final product can deteriorate.

In the first step, reflected light is collected by a lens and converted to an electrical signal at the camera. The cameraman must maintain sharp focus, or else the first deterioration will take place. The output of all cameras must be properly matched for balance and smooth switching. This matching is the responsibility of the video operator who must also correct for contrast, brightness levels, etc.

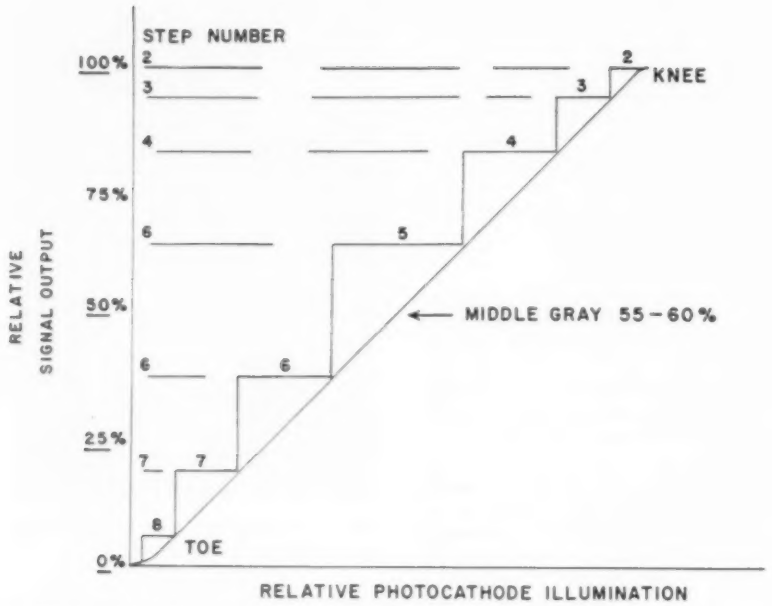

Fig. 1. Response characteristics curve.

Before the video signal travels through the switcher, it often goes through a special effects amplifier, another source of potential trouble. Finally, the video image appears on the face of the kinescope in the kine recorder where a special camera records the image on film. Equipments and techniques are continually being modified to improve the finished product.

Some of the procedures followed in making a military recording may differ from those followed in industrial productions. In military practice, new image orthicons are tested for blemishes and if a tube falls below standard it is replaced. If found satisfactory, the tube is given a breaking-in period of about 50 hours which brings the tube to its best output in resolution and noise-free video.

Video amplifiers are completely swept so that no details will be lost in the four corners of this final film. Camera viewfinders and control-room monitors are masked to compensate for the cropping of a frame in printing and reducing from 35mm to 16mm.

In matching cameras, image orthicons are operated using the maximum amount of the linear portion of their characteristics curve (see Fig. 1). Steps 1 and 2 of the gray scale are compressed. This is done because less detail appears in the white portion of the gray scale and maximum blooming appears in this area. Steps 3 through 8 are then aligned on the linear portion of the curve to produce maximum information.

A four-channel waveform monitor is used to match the video levels from the three cameras. At a glance, the video operator can see if levels are matched. In recording, a zero pedestal (black) is used instead of the 10% pedestal normally used by the networks.

Film Processing

Until recently, TV recordings for military use were made on 35mm variable-density sound negative stock. This film is normally developed to a gamma of 0.70 or 0.80 in a Kodak D-76 type developer. Because the kinescope (10NP11) does not produce much light, the recording camera lens aperture was at a constant maximum of $f/2.3$. Also, the video voltage of the kinescope was driven to a near maximum to achieve sufficient light on the face of the tube for proper exposure of the sound recording stock. This resulted, to some extent, in a loss of resolution and depth of field.

In an effort to compensate for the underexposure problem, the film was processed in a Kodak D-19 type developer to a gamma of about 1.20. This somewhat improved the gray scale but distorted the characteristic curve of the sound recording stock. At present, kinescope recordings are made using a panchromatic negative of the Plus X or Superior 2 type, both of which have been found to be satisfactory.

A well-exposed negative is obtained when developed in a Kodak D-76 type developer gamma of 0.65 to 0.67. This procedure makes it possible to retain the desirable characteristic curve of the emulsion with no objectionable increase in grain as compared to a print made from a sound recording negative.

Greater film sensitivity permits the use of less light, allowing stopping down to about $f/4$ which results in increased depth of field and permits operating the kinescope with a lower bias and video voltage requirement and enables reducing the size of the scanning aperture, giving considerable improvement in resolution of the scanned image. Blooming effect is reduced with lower video voltages and the kinescope has a longer life.

Present Developments and Prospects

We are experimenting with a 24-frame/sec scanning rate to replace the normal rate of 30. With a 24-cycle system, the television frame rate is matched to that of standard film cameras, eliminating any existing shutter bar. Reduced scanning rate can lead to further improvements in resolution and depth of field.

To alleviate the problems of frame cropping during printing and reduction of the 35mm negative to 16mm film for release printing, we are building an electronic mask, using delay multivibrators, which will enable the director to achieve proper framing.

Conclusion

Considerable progress has been made in improving the quality of kinescope recording for military use but much remains to be done. The development of high-quality video-tape recording will be an important step forward. Problems are being met and overcome by the modification of present equipment and the exploration of all possible avenues to produce films by TV recording.

Army Television Research and Development

By WILLIAM A. HUBER
and RICHARD B. LE VINO

Military TV application requires equipment with technical and operational characteristics that differ from those found in industry. To produce such equipment the U.S. Army Signal Research and Development Laboratory conducts a comprehensive research and development program that embraces all phases of the art. A technical survey of this activity is given, indicating those technological limitations that now exist and are seriously impeding the military applications of television as well as the developed and proposed methods of solution.

The U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., has cognizance of all television research and development activities in the Army and conducts a comprehensive television research and development program. Work carried on by scientists at USASRDL and various commercial engineering facilities, laboratories and universities throughout the country contributes to this program. Research is directed toward those technological limitations that now exist and seriously impede practical application of television to pertinent military requirements.

One example is that of reconnaissance applications in which the TV camera, transmitter, and associated equipment must be as small, lightweight, and efficient as possible for operation in the restricted space of a small aircraft or drone. This equipment must be designed for unattended operation and must include automatic data encoders and remote control facilities which can be operated from a receiving location.

Any complexity in a military TV system of this type must be incorporated in the receiving equipment where power and space requirements are generally not so stringent, in contrast to commercial broadcasting systems where it is usually preferable to engineer complexities into the transmitting equipment because of the relatively few transmitters as compared to the large number of receivers, and the availability of trained personnel for operation and maintenance.

Among technological advances made in military television as a result of Signal Corps research and development activities is the development of a military image-orthicon camera. Military TV reconnaissance application demands an image-orthicon type of camera because of resolution and light sensitivity requirements. Physically, the available image-orthicon cameras were too large and heavy and their power requirements were too high for reconnaissance application. It was, therefore, necessary to develop a military image-orthicon camera.

Presented on October 7, 1957, at the Society's Convention at Philadelphia by William A. Huber (who read the paper), U.S. Army Signal Research and Development Laboratory, Ft. Monmouth, N.J., and Richard B. Le Vino, formerly with the USASRDL, now at Smith-Corona, Inc., Product Planning Dept., 701 Washington St., Syracuse, N.Y.
(This paper was received on August 29, 1957.)

Military TV Camera

An exposed view of the military television camera is shown in Fig. 1. Camera construction features a fold-out type of chassis which permits free access for servicing. The typical camera functional units such as sync generator, deflection circuits, video amplifier, and power supply are sectionalized on individual subchassis.

To facilitate initial manual adjustment and subsequent remote adjustment of the electrical functions of the camera, appropriate potentiometers are mounted in a separate control box. Remote adjustment of these functional controls is achieved by motors mounted at the rear of each potentiometer. The motors are energized through a separate radio control channel. The camera sync system is capable of operating as either a master or slave depending on the number of cameras used and their arrangement in the system. The output of the camera is designed for direct application to the transmitter and is capable of producing a video picture with a limiting resolution of 600 lines. A few of these cameras have been produced by The Austin Co. of New York.

Picture Synchronization

While conducting airborne-to-ground TV tests on an experimental reconnaissance system, it was noted that much pictorial information was lost, even within the normal operating range of the system, because of instability in the displayed picture. It was found that picture instability was due mainly to large fluctuations in the received sync signal, resulting from variations in the exposed radiation pattern from the transmitter. This was caused chiefly by alterations in the aircraft flight course. In commercial practice sync techniques

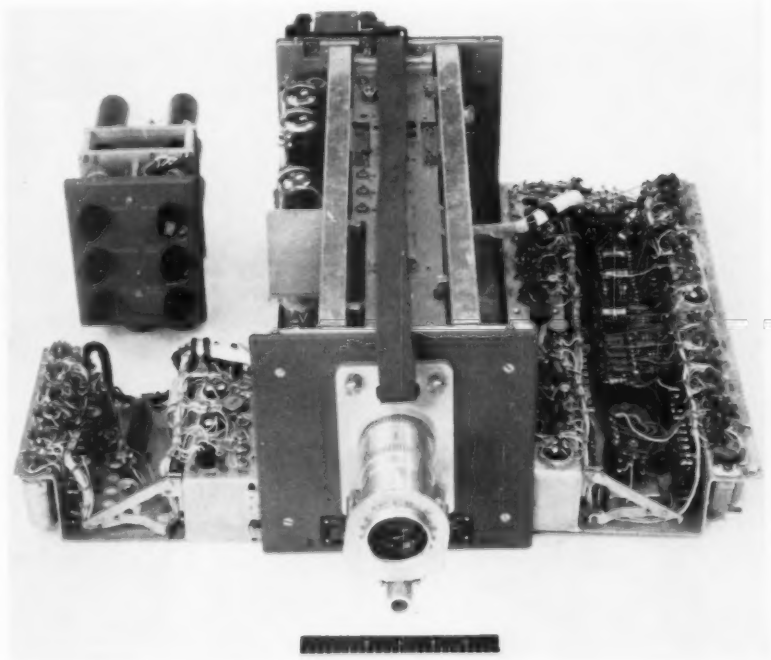

Fig. 1. Military image-orthicon camera.

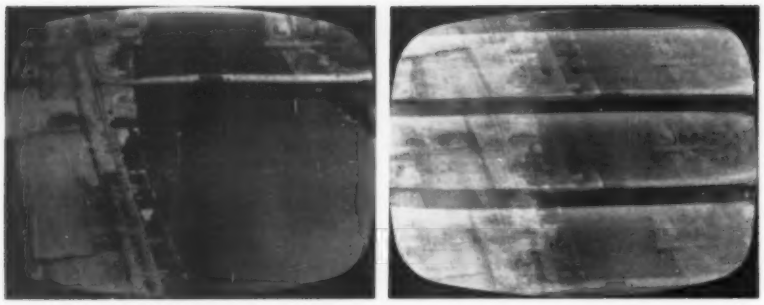

Fig. 2. Comparison data showing superior performance of lfs system (on the left) during poor signal conditions.

have been developed for fixed point-to-point operation.

These techniques generally rely on the stabilizing effects of a local oscillator having the short-term free-running stability of a one-frame period. In military applications where the transmitting, and possibly the receiving, locations are mobile, TV sync requirements demand a short-term free-running oscillator stability of many frame periods. This type of oscillator performance was obtained by the use of a local frequency stabilizer unit developed at USASRDL. This unit, generally referred to as an lfs unit, obtained its short-term free-running stability by means of a crystal oscillator which was electronically and mechanically controlled. Figure 2 illustrates the superior operation of the lfs system.

Stabilized Camera Mounting

Additional requirements for aerial reconnaissance are related to camera mounting, positioning, and stability with respect to aircraft motion. A research and development program was undertaken in cooperation with the Radio Corp. of America, Camden, N. J., for the study and subsequent development of such a camera mounting. As a result of this endeavor the stabilizer assembly shown in Fig. 3 was developed. This stabilized mount supports the TV camera in a clear plastic dome beneath the aircraft and provides positioning within a hemisphere by means of rotation about the train and elevation axis.

The motion can be controlled from within the aircraft, when used for attended operation, or from the ground receiving station when operated unattended. Stability against change of course, pitch or roll is effected along the respective axis. The degree of stability achieved during flight tests was $\pm 0.5°$ when the aircraft maneuvered at amplitudes of $\pm 15°$. The torque and control necessary to accomplish the required stability are obtained from a servo system integrated with the aiming system of the aircraft. The stability sensing for the camera mount is obtained from gyros.

Video Strobe Photographic Recorder

In order to take full advantage of the limited resolution capabilities of the television system it is customary to operate with a lens having as narrow an angle of view as is consistent with other operational requirements. In aerial reconnaissance applications this means that the displayed information is moving at a rate just below that which would produce distortion due to the scanning rate and lag characteristics of the TV system. This type of operational procedure, while useful, is not adequate for all observational requirements because of frequent need for a more extended view of a given area. If extended area viewing is desired it can be obtained by manual adjustment of the camera position through the remote-control system.

There are times when the importance of the information being televised is sufficient to warrant extended study beyond the time provided by manual camera panning. For these conditions a permanent record of the televised information is desirable.

To fulfill this military requirement, a video strobe photographic recorder was developed under a contract with RCA, Camden, N.J. This recorder is located at the receiving station and is operated by pushbutton control. Both single- and multiple-frame operation are provided by means of a function switch. Figure 4

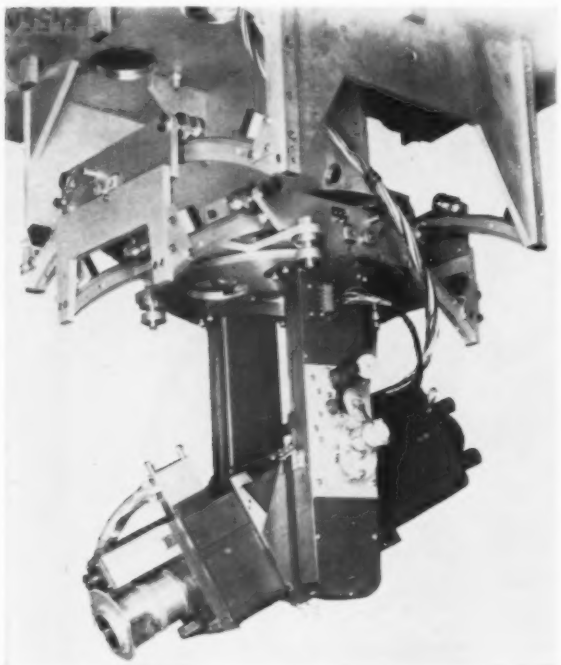

Fig. 3. Camera stabilizer assembly.

Fig. 4. Video strobe photographic recorder.

shows the pertinent components of the video-strobe photographic recorder. The TV picture is displayed on a 17-in. monitor and photographed with a modified Bell & Howell 35mm camera. This camera has a spring motor for film transport which has been provided with an automatic electric motor wind. The electrical circuits of the video strobe recorder are especially designed to provide maximum picture stability for photographing. Electrical gamma stretch controls are provided to assure optimum picture tone gradations. Either a positive or negative picture can be displayed. The multiple-picture recording rate can be adjusted between the limits of 1 to 6 pictures per second. Through the use of this multiple recording feature, and the forward motion of the aircraft, it is possible to obtain stereo effects from sequential photographs when appropriately viewed.

TV AM-FM Propagation Tests

In military television much engineering experience had been gained through the use of AM modulated transmitters and it was thought desirable to obtain comparative experience with FM modulated transmitters. Admiral Corp. of Chicago contracted for the development of corresponding AM and FM transmitters operating in the 780- to 900-mc region. This program made it possible to compare the operational performance of both systems under field conditions.

The transmitters were designed to utilize identical output-type tubes and to be approximately equal in size, weight and power input requirements. An AM modulated transmitter was developed which produced a black-level carrier power of 25 w while the companion FM modulated transmitter produced a carrier of 20 w. Engineering field tests were performed by USASRDL personnel to determine the relative merits of the two systems in actual field operation. These tests were conducted in the Ft. Monmouth, N.J., area and included operation of both transmitters simultaneously from an airborne Army H-19 Helicopter. Identical antennas were mounted on the underside of the helicopter for each transmitter, and identical video information was fed simultaneously to each modulator from a single TV camera.

The receiving station was housed in an Army Type M-109 vehicle and included an AM and FM receiver which had identical antennas, video amplifiers and display units. Various measuring and recording equipments were also available. The receiving station was powered by an Army Type PE-95 auxiliary power unit. Operational data were obtained by locating the receiving station at Monmouth County Airport, Belmar, N.J., and telecasting identical information over both transmitters as the helicopter proceeded from take-off to various ranges at specified altitudes. The AM and FM displays were mounted side by side and simultaneously photographed to obtain a record of the performance of each system. Figure 5 shows the front of the U.S. Army Signal Research and Development Laboratory at Ft. Monmouth. The photograph on the left was transmitted by FM carrier and that on the right by AM carrier. The r-f transmission distance for these data was 8 miles. The two systems seem to be about equal in performance.

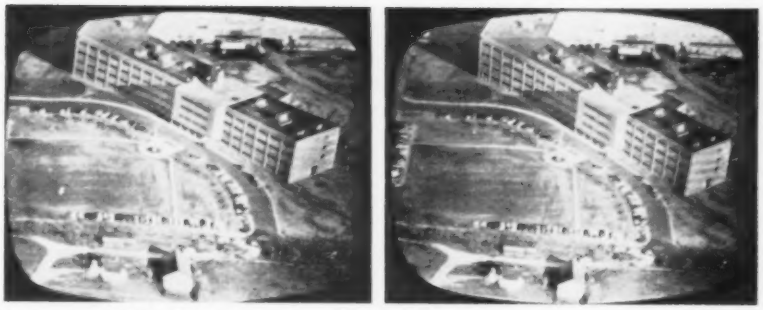

Fig. 5. Comparison data showing equal performance of FM system, on the left, and AM system on the right, for r-f range of 8 miles at an altitude of 1000 ft.

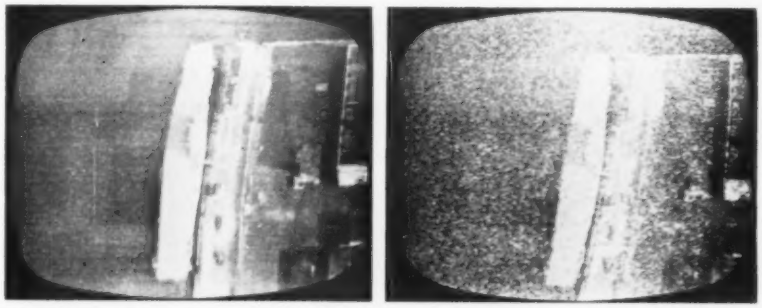

Fig. 6. Comparison data showing superior performance of FM system, on the left, and AM system on the right, for r-f range of 35 miles at an altitude of 3000 ft.

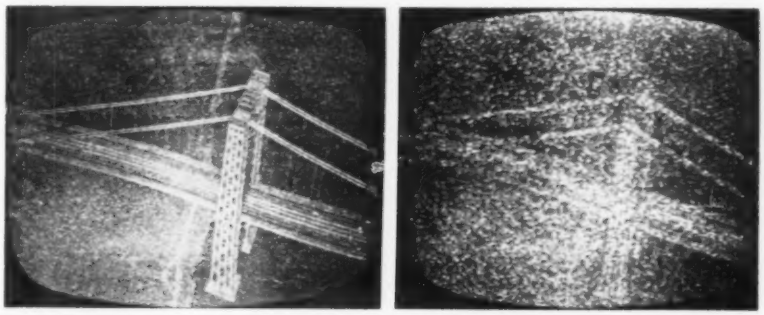

Fig. 7. Comparison data showing performance of FM system on the left, and AM system on the right, for r-f range of 50 miles at an altitude of 4000 ft.

This type of equivalent performance was consistently obtained throughout the tests for transmission ranges up to 10 miles. It should be noted that this series of pictures was transmitted with r-f carriers powered at 25 w or less and the complete system, including camera, transmitter and associated components, weighed about 125 lb. Figure 6 is an aerial view of an aircraft carrier docked in the New York area. Under these conditions of 35 miles range and 3000 ft altitude, the superiority of the FM transmission is evident. Figure 7 is a view of the George Washington Bridge from an altitude of 4000 ft and an r-f transmission range of 50 miles. While the FM picture shows the effects of attenuation by the presence of noise, it is still to be preferred over the AM picture. At a slightly extended range the FM signal dropped out completely while the AM signal was barely discernible. Only at this extended range was the AM signal superior but this was of little practical value because of the high noise content.

Military TV Systems

While many technical limitations have been overcome for the application of television techniques to the solution of

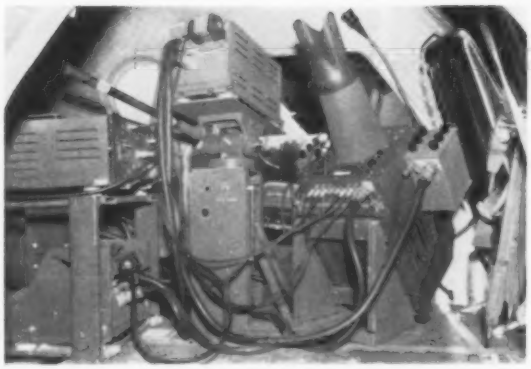

Fig. 8. Airborne installation of Army integrated "air-ground" TV system.

Fig. 9. Picture resulting from low-channel video transmission.

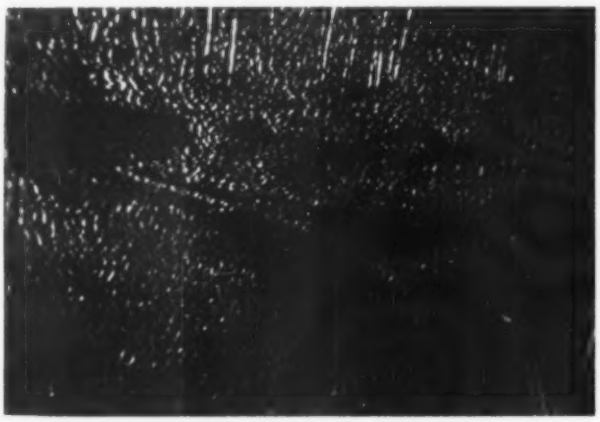

Fig. 10. Picture resulting from high-channel video transmission.

Fig. 11. Composite picture resulting from combined high- and low-channel video.

certain military problems, the improvements cited so far are related to equipment components and before their military value can be determined it is necessary to integrate the improved components into tactical operational systems. There follows a brief description of a few of these systems which are all experimental in nature and range in complexity from the portable Tele-Scout to the composite airborne and ground system which contains a multiplicity of vehicles for housing and transporting the equipment.

The transmitter of the Tele-Scout is strapped to the back leaving both hands free for operation of the camera. The equipment weighs 50 lb, and will operate for about two hours on one battery charge. The maximum range of the equipment is from one to two miles depending on the terrain.

The ground equipment of a more complex system called AG-2 consists of three complete integrated TV systems each capable of independent operation and mobility. Each of these ground systems has its own microwave relay link which provides extended ground coverage. The airborne portion of the integrated system developed at USASRDL is installed in an Army Type L-20 Aircraft. Figure 8 is an interior view of the aircraft with TV equipment installed. Equipment similar to that found in the AG-2 system but selected for pertinent operational requirements of the 101st Airborne Division has been integrated into a functional system that is now undergoing tests by that organization. All the above systems, with the exception of the airborne portions, were developed under contract with RCA.

To determine the feasibility of using TV as a visual aid for remotely controlled driving of a ground vehicle and the subsequent transmission of surveillance information from the vehicle back to the base station, an appropriate system was developed by contract by Allen B. Du Mont Laboratories. This equipment was experimental and designed specifically for field engineering investigation, the results of which established the practicability of using television as a visual sensor for remote ground vehicular driving. The practicability of using television for remote unattended surveillance was qualified to the extent that success of application depended on required angle of view, object size, object to background contrast and point of observation. The seriousness of r-f attenuation effects at UHF frequencies for signal propagation between ground-to-ground locations was evident throughout all these tests.

While all the above-mentioned systems are tactical in nature, the Signal Corps research and development programs have also extended into fields of TV instrumentation and psychological warfare.

Research

The scope of this program is basically that of equipment development and it has been timed for application to the present and immediate future military requirements. In order to fulfill military TV requirements beyond the immediate future it is necessary that the present Signal Corps activities also embrace a research program designed to satisfy these obligations. In recognition of this responsibility the Signal Corps is sponsoring a military TV research program at Denver Research Institute. This program is, in general, directed toward the development of techniques for improving radio-frequency spectrum utilization in military TV applications.

The program includes such activities

as: video signal quantizing, digital encoding and decoding, modulation techniques with emphasis on pulse code and quadrature carrier methods, transmission by radio-frequency spectrum dispersion, information theory, polarized r-f carrier applications, and video storage techniques. The motivating factor of this research and engineering investigation program is that military TV, in common with other services using electromagnetic radiation, is limited by the problem of finding adequate spectrum space at practical r-f carrier frequencies. The wide frequency band requirement of these services generally eliminates the possibility of using the already crowded VHF band. In some types of communication, such as low power ground-to-ground television, this is a distinct disadvantage due to the unfavorable propagation characteristics of the UHF frequencies under these terrain conditions.

A method has been suggested by the senior author for minimizing this difficulty by the employment of r-f spectrum dispersion. This method effects a frequency division of the wideband video information into separate channels with reduced frequency limits, and the subsequent transmission of this divided intelligence on multiple r-f carriers. By use of this technique there is the possibility of allotting the r-f carrier that is modulated with the low-frequency picture components, to a position of lower r-f frequency than would have been originally possible. Advantage is thereby taken of the superior propagation characteristics of lower r-f frequencies as carriers for the more important picture information; the less important picture information is transmitted at higher carrier frequencies.

Denver Research Institute has conducted several short-range tests by transmitting video analog information by spectrum dispersion. This was accomplished by developing a video band separation filter with a low channel bandpass of 15 cycles to 1 mc and a complementary high channel bandpass from 1 to 4 mc. This filter is inserted at the output of the camera to achieve the high and low video frequency band separation. Figure 9 shows a picture resulting from low channel video. The complementary picture resulting from the high channel video is shown in Fig. 10. Pre-emphasis of the high-frequency components can be readily applied to this signal. The information shown in Figs. 9 and 10 was transmitted over separate links and combined to form the composite picture shown in Fig. 11. While the above pictorial information was transmitted in analog form the technique can be readily adapted to digital signals.

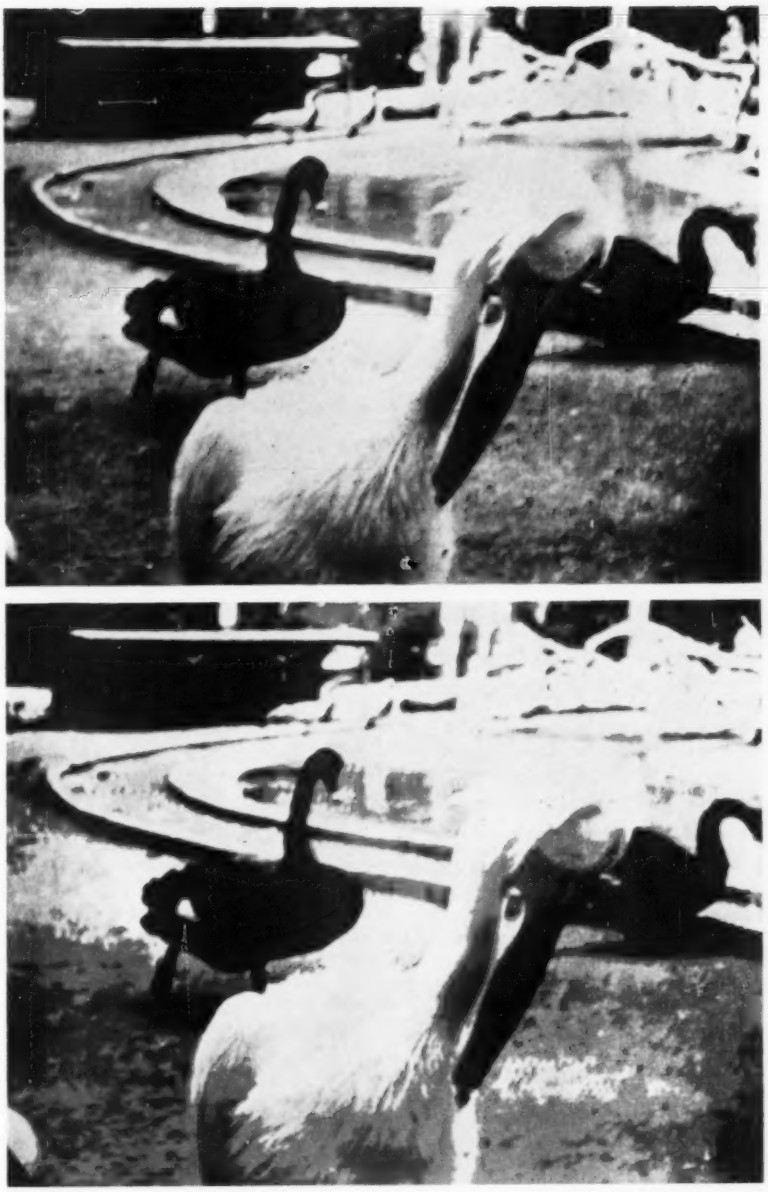

Fig 12. Comparative results of analog and 8-level quantized pictures transmitted with a 3-binary digital system.

Signal Corps-sponsored work at the Denver Research Institute in digital TV has resulted in the development of a television electronic binary encoder known as TEBE, the function of which is to process the original continuous video signal into that of a discrete binary digital form. Television signals processed by TEBE have been transmitted by pulse code modulation using three binary digits. It was found that pictures transmitted by three binary digits are adequate for many military applications. Figure 12 illustrates comparative results of analog and 8-level quantized pictures transmitted with a binary digital system.

Conclusion

This brief discussion has been concerned with reporting on present research and technological advances made in military television. We are confident that television will play an important role in future military activities. How soon this will come about and to what degree depends on to what extent future research and development are successful in overcoming present limitations on TV camera resolution and sensitivity and in achieving more efficient methods of transmission, reduction in equipment complexity, and increased system operational reliability.

Television for Use Under Rugged Environmental Conditions

By JOHN P. DAY
and FRANK R. PIKE

A variety of applications has been made of television equipment under extreme environments. The generally desirable characteristics of these equipments are examined. Design features of a system built for rugged usage are described.

INDUSTRIAL TELEVISION equipment was originally designed to provide a tool for visual communication. These early systems were adequate for monitoring smoke stacks, data transmission, plant security and many "general observation" uses. With the possible exception of a system designed especially for power plant furnace observation, little attention was given to developing a closed-circuit system that would perform under typical rugged environments found in both military and industrial applications.

The strategic advantage of using portable closed-circuit TV in combat areas has brought a Jules Verne approach to the solution of some of the design concepts. The increase of military usage and certain severe industrial uses focused attention on the need for ruggedized industrial TV systems.

Types of Packaging

There are three main types of system packaging (Fig. 1), each with its advantages and disadvantages.

In Type 1, the self-contained camera has the advantage of requiring only a single coaxial cable between the camera and the monitoring receiver besides requiring a minimum of equipment. For rugged environments, however, the number of tubes and the complexity of the circuits make the camera too sensitive to vibration and shock. Since all the controls are on the camera, it is inconvenient if not impossible to adjust the system while in operation.

Type 2 uses the camera and master monitor. This packaging is more practical for use in rugged environments, chiefly since there is a minimum of parts in the camera and all the controls are removed to the control point at the master monitor. Some of the circuits perform common functions for both the camera and the control monitor, and therefore a monitor must be used at this point whether required or not.

The Type 3 system, of three separate units, is extremely flexible and has the advantage of remoting the camera and the camera control from the monitor. Thus a simple panel at the monitor gives remote operation not only for the camera accessories but the camera control unit as well. This system also allows for the selection of any type or size of monitor desired.

The Type 3 system continues to gain

Presented on October 7, 1957, at the Society's Convention at Philadelphia by John P. Day and Frank R. Pike (who read the paper), KIN TEL, a Division of Cohu Electronics Co., Box 623, San Diego 12, Calif.
(This paper was received on October 11, 1957.)

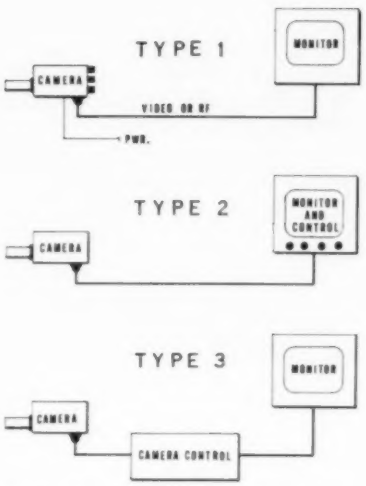

Fig. 1. Three main types of system packaging:

Type 1 — Advantages	*Disadvantages*
Simplicity	Inconvenient to adjust
Low power consumption	Servicing difficult
Minimum equipment	Not very adaptable to multiple camera or switching systems
Low cost of basic system	Usually noninterlaced system
	Difficult to ruggedize

Type 2 — Advantages	*Disadvantages*
Minimum parts in camera	Expensive camera cable
Minimum equipment in hazardous location	Integrated monitor and camera control unit
Easy to ruggedize camera	Requires monitor at control point
Easy to adjust	
Easy to service	

Type 3 — Advantages	*Disadvantages*
Extremely flexible system arrangement	Expensive cable
Minimum parts in camera	More circuitry than Type 1 or Type 2
Minimum equipment in hazardous location	
Easy to service	
Easy to adjust	
Easy to ruggedize camera	

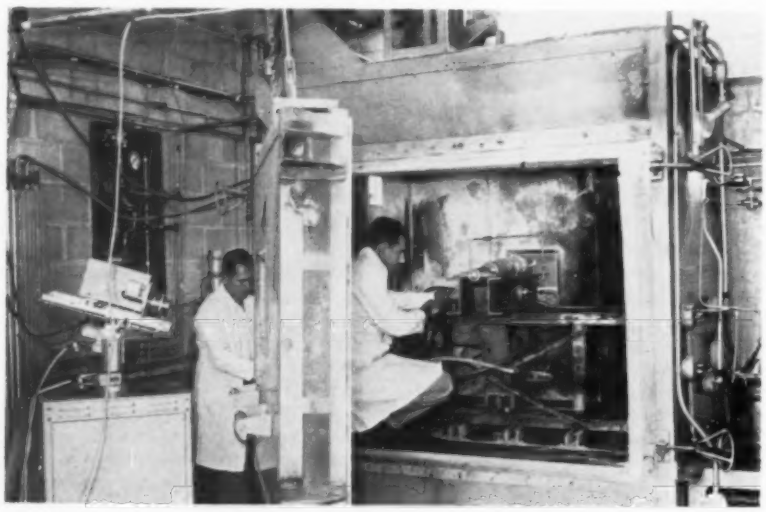

Fig. 2. KIN TEL industrial TV used at Autonetics Co. to observe high-temperature hydraulic system test.

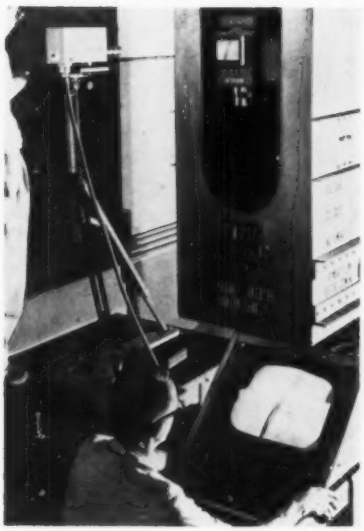

Fig. 3. Observation of schlieren apparatus during wind tunnel tests of ballistics models.

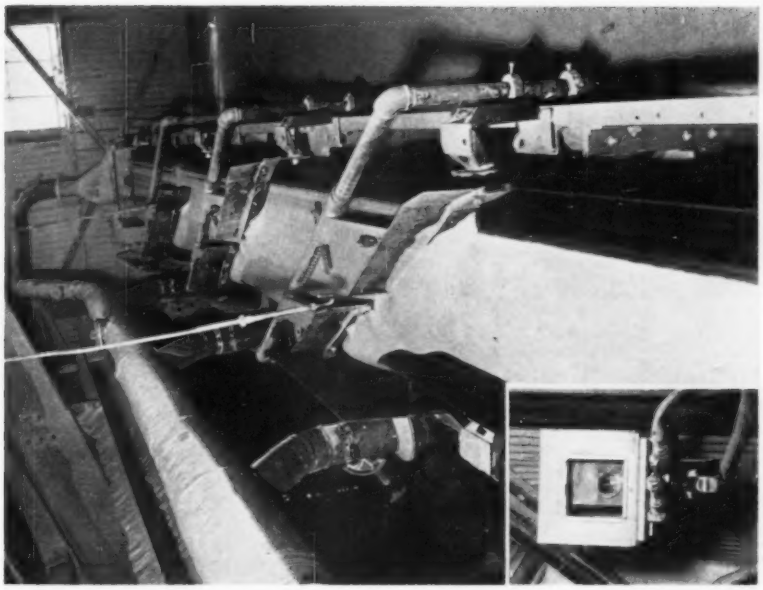

Fig. 4. Dustproof housing and camera at American Pot Ash & Chemical Co.

the approval of equipment manufacturers because it makes it possible to treat each unit according to where it is to be used; for example, the camera may be located at a point where vibration and dust present a problem and the control unit might be subjected only to dust and the monitor located at a remote point free from any contamination. The expense of special packaging is thus minimized.

Use of Standard Equipment

In many instances a standard TV camera may be isolated from a rugged environment and accomplish the same results as if it were placed in the actual environment. Such is the case in the installation in a hydraulics test laboratory (Fig. 2). The TV system is used to view high-temperature hydraulic circuits and equipment in a testing oven room. Safety requirements and the nature of the tests prevent personnel from being in the oven room. The camera is located within the oven room while the control unit and monitor are located in the adjacent control room. The camera is mounted on a special pan and tilt unit to attain greater range of visibility in a hazardous test area.

Tests at temperatures up to 1200 F and down to −105 F are conducted in this laboratory. Permanent electrical wiring, push-pull rods and motorized valves are employed to control, test, and record data. Tests too difficult to observe directly are monitored by this system. A similar installation involves observation of models in a wind tunnel (Fig. 5) through a schlieren optic system. In each of these applications a rugged atmosphere is observed using standard unprotected equipment.

Isolating TV Equipment

Other methods have been used for isolating the camera from rugged environments. For example, a dustproof housing (Fig. 4) was designed to isolate cameras used for observation in a dust-contaminated area. An acoustical housing (Fig. 5) was developed to permit the use of TV cameras in high-noise areas. A heavy-duty pan and tilt unit, designed as a companion unit (Fig. 6), permitted remote positioning of the camera in a high-noise atmosphere.

An underwater housing (Figs. 7 and 8) makes it possible to use the camera hundreds of feet below the surface of the water. Special cable and remote lens iris and focus control add flexibility to this system. Underwater mercury vapor lights and underwater pan and tilt units are available.

The first efforts to "ruggedize" a standard camera employed special mounting and shielding of the camera preamplifier tubes such as the 4BQ7's. Naturally the search for a more rugged camera led to the use of subminiature tubes. Direct soldering of tube leads and special tube clamps made it possible to produce a camera that would withstand ambient noise levels up to 160 db. A word of caution should be noted here. It is not sufficient to know the ambient noise level in decibels when evaluating the performance of a TV camera in high-noise environments. The power noise spectrum varies depending upon the application. A camera may work very well when used at a rocket test stand at a noise level of 160 db, but that same camera may produce noise bars or microphonics when used in a jet engine test cell where the noise level is the same. It is generally

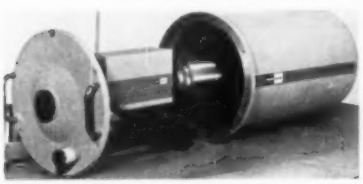

Fig. 5. Acoustical housing to shield camera in high-noise areas.

Fig. 6. Heavy-duty pan and tilt head with camera in acoustical housing.

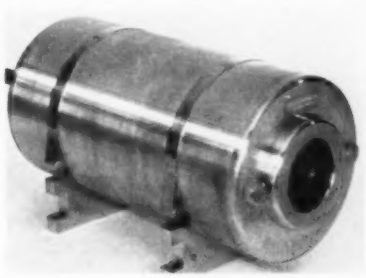

Fig. 7. Brass underwater housing.

Fig. 8. Camera used underwater on "Wide Wide World" TV show, in cooperation with TV Branch of U. S. Navy Bureau of Ships.

impractical to analyze the noise spectrum; however, performance comparisons have been used as a normal criterion.

These special design techniques have made possible good performance of vidicon cameras in areas subjected to an average white noise level of 175 db and shock in the three planes of 15 G's. Figure 9 shows a typical high-noise rocket test stand installation. Military research and development programs continually demands closed-circuit television cameras that will withstand ever-increasing rugged conditions.

A New Ruggedized Camera

No one camera can be designed to operate unprotected in all environments, but presently available equipment will solve many problems of remote observation in rugged environments. A small rugged camera for special application has been designed (Fig. 10).

This camera weighs approximately 4 lb and is $3\frac{1}{2}$ by 4 by 8 in. in size. It is completely dustproof and splashproof; in fact, the camera can be immersed in shallow water if the lens is properly sealed. Experiments indicate that this camera can withstand temperatures from −55 C to +170 C and will still operate satisfactorily when the temperature returns to the operating limits of the vidicon. Present operating limits of the vidicon are from −40 C to +60 C. In the future, vidicons should be available with extended temperature limits. This camera can be fastened to a missile frame and can withstand the vibration and shock encountered, and is capable of producing a picture with a horizontal resolution in excess of 600 lines.

Where high-quality pictures are not mandatory, the smaller $\frac{1}{2}$-in. vidicons offer great promise for further miniaturization of ruggedized television cameras.

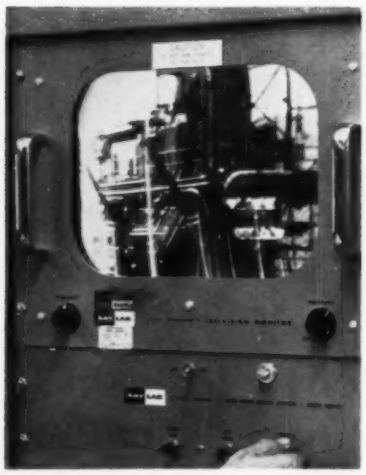

Fig. 9. High-noise rocket test stand installation at Rocketdyne Div., North American Aviation, Inc.

Fig. 10. Small rugged camera for special applications.

Television Viewing of Rocket Engine Tests

By JAY P. MITCHELL

A remotely operated closed-circuit television system has been especially designed for viewing rocket engines under test conditions. The camera incorporates a zoom lens system, pan and tilt pedestal, and a weatherproof and soundproof camera housing. All camera functions, electrical, optical and mechanical, are completely controlled from a master control console. The problem of acoustic shielding against noise at levels around 200 db is described.

THE USE OF closed-circuit TV systems for remote observation has been adapted to many situations where, because of environmental conditions, a close study of an object or action would otherwise be impossible.

One of these situations is the viewing of rocket engines under test conditions. A major consideration in the design of the TV system is that of extremely high sound level conditions since sound levels as high as 200 db may be expected under test conditions. An additional consideration is that the camera must be able to cover a wide field of vision as well as provide close-up observation of an object. There should also be maximum coverage of the horizontal and vertical field of vision around the camera site. Since the camera is located outdoors, weatherproof camera housing is a necessity.

The controls for operating the TV system are located at a master control observation center several hundred feet from the rocket engine test site. Multiconductor cables connect the units of the system to the control center. The complete system is shown by block diagram in Fig. 1.

A vidicon-type camera chain of the Diamond Utiliscope Model 500 Series is used. This camera was chosen because of its small physical size and easy adaptation to remote operations.

Presented on October 7, 1957, at the Society's Convention at Philadelphia by Jay P. Mitchell, Diamond Power Specialty Corp., Box 415, Lancaster, Ohio.
(This paper was received on September 3, 1957.)

Sound Proofing

The camera is mounted on small rubber shock mounts inside a cylindrical housing of heavy-gauge steel. The shock-mounting is arranged to give shock protection in the longitudinal, lateral, and vertical directions. Another reason for internal shock-mounting is to prevent transmission of acoustic energy to the camera from the housing which would pick up noise radiated from the test cell. The interior of the steel housing is coated with a rubber compound to act as an absorber of external sound, and to prevent re-radiation inward to the camera.

To provide ventilation, holes were bored along the length and top of the housing necessitating a weather shield to prevent entrance of water into the housing. This shield is coated on the bottom with the rubberized compound and attached to the cylindrical housing by rubber shock-mounts. It also acts as

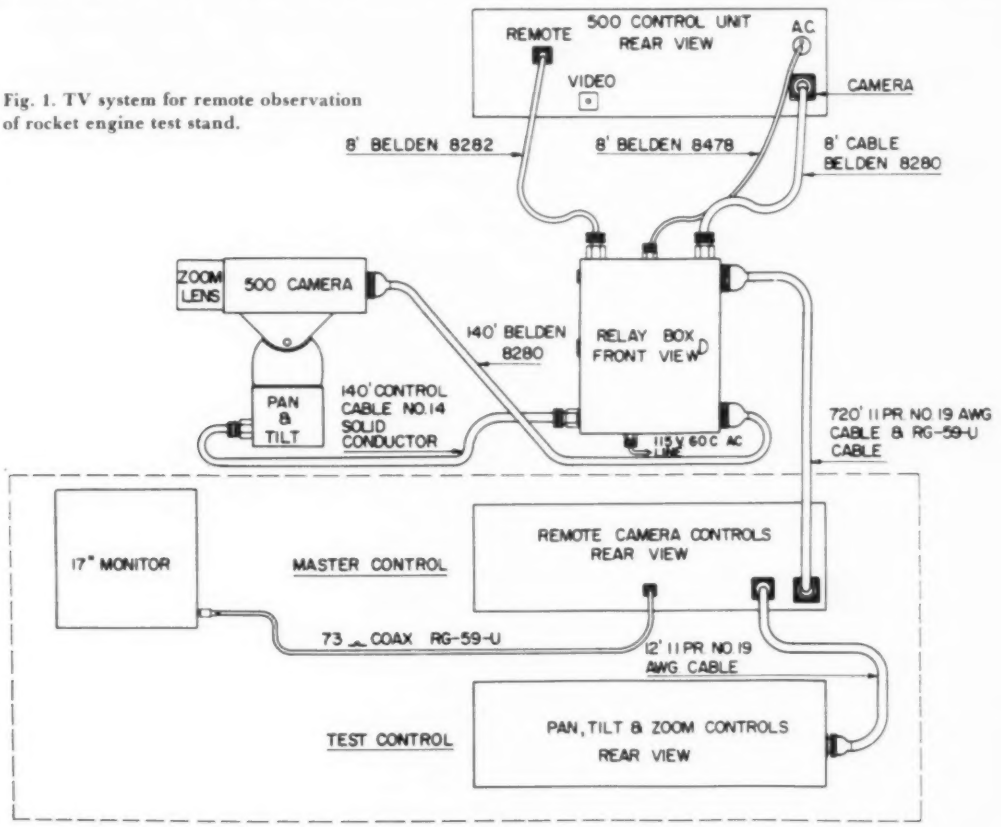

Fig. 1. TV system for remote observation of rocket engine test stand.

Fig. 2. Camera housing and pan and tilt pedestal.

a low-pass acoustic filter to reduce entry of noise through the vent holes.

The camera housing assembly is mounted on a motorized pan and tilt pedestal. A rubber pad is inserted between the housing and pedestal mounting plates to provide additional protection against vibration. The resilience of this pad is low to avoid interaction with the internal shock-mounts.

The front end of the camera housing is fitted with a thick glass window set in fiber bushings.

Optical System

The camera is equipped with a Perkin-Elmer zoom lens system. Small fractional horsepower d-c motors operate the zoom and zoom focus mechanism of the lens system. The focal length range of the lens is 30 to 150mm with a field of view of 30° at 30mm and 6° at 150mm. The maximum aperture is $f/2.7$ at 30 to 80mm focal length and $f/4.5$ at 150mm.* The lens iris is set at maximum aperture, since the TV equipment contains an automatic light level compensating circuit.

To fulfill the requirement for maximum coverage for the horizontal and vertical field of vision around the camera site, a motorized pan and tilt pedestal is used. This unit is capable of panning the camera through 320° and tilting it 45° above and below the horizontal plane of vision. This pedestal is constructed to support the weight of the camera and its housing (Fig. 2) (about 100 lb) and is weatherproof.

Operating Controls

To control operation of the pan and tilt motors, a relay control circuit is necessary. These relays are mounted in a box which also serves as a junction point for the multiconductor camera control cables. This unit is located in an area adjacent to the television control unit (Fig. 1). This area would normally be a protected location so that no special attention to shock mounting of the relays is required. All a-c power required to operate the TV system is fed into the relay control box and distributed from it.

An electrical braking circuit is included in the motor control circuit to prevent coasting of the tilt motor. A silicon rectifier rated at 5 amp supplies the direct current to obtain braking action when the tilt switch, located at the master control center, is released.

The control panel on which the tilt switch is located also contains the pan control switch, the power chassis and control switches for the zoom lens optical system. Two control switches are required to set the lens focusing so that the picture is constantly in focus as the lens is zoomed back and forth on the object by the zoom control switch. One switch operates the zoom focus motor and the other switch operates a fractional horsepower a-c motor in the camera. The a-c motor moves the camera vidicon tube with respect to the lens system. A selector switch gives the operator a choice of two speeds for the lens zoom control.

A second control panel is supplied with this system and this panel contains electrical operating functions for the camera, such as beam, target, electrical focus, blanking level, and the a-c power on-off switch.

Camera Chain

The vidicon camera chain consists of two units: a small camera, which weighs about 11 lb, and a control unit, which is constructed so that it can be rack mounted. The camera contains three video amplifier stages: two stages of blanking signal amplification, and the fractional horsepower focus motor. The amplifier stages utilize three subminiature tubes and one silicon transistor.

The control unit contains additional stages of video amplification, vertical frequency, and horizontal frequency scan circuits, automatic light level control circuit, vidicon protection circuit, transistor timer to generate the horizontal and vertical frequencies drive pulses for 525-line, 30 frames/sec interlaced scanning, and an electronically regulated power supply. The electrical controls for camera functions are normally located on the control unit, but in this installation, and others where remote control is desirable, controls are provided by a multiconductor cable. The camera and control unit are interconnected by a Belden Type 8280 multiconductor TV camera cable.

Summary

This television system was designed for a special application involving several complete systems of the type described here. As is generally the case in special applications of this nature, a complete solution of all problems arising in the field must be worked out during installation and initial operation of the equipment, under actual operating conditions. Undoubtedly, the use of closed-circuit industrial television for the study of rocket engine performance will be of increasing value in the furthering of scientific knowledge in this field.

* *Instruction Manual for the Auto-Zoom Lens Model 16TV*, Perkin-Elmer Corp.

Some Aspects of the Application of Television to the Tracking of Guided Missiles

By HOWARD L. ROBERTS

An investigation to determine whether television could increase the range of optical tracking devices has been conducted for the U.S. Navy Air Missile Test Center, Point Mugu, Calif., by the Denver Research Institute. Range is limited by loss of object contrast. An expression is developed which indicates that electro-optical devices can detect lower contrasts than the human eye. The parameters of a TV system for aerial tracking are discussed. Both greater and lesser ranges were obtained in experiments. Other means by which TV performance might be improved are discussed.

THE TRACKING of guided missiles and other aircraft by optical devices is one of the methods used to determine the flight paths of test vehicles. Radar and some thirty-odd other electronic trajectory evaluation systems are also used, but the optical method finds wide acceptance because of its accuracy. However, the maximum range of the optical tracking devices is considerably less than that of other systems. It was with the thought that an increase in range might be obtained by interposing a television system between the objective lens of a theodolite and the recording camera, or the eye of the tracking operator, that a contract to explore such a possibility was entered into between the U.S. Navy Air Missile Test Center, Point Mugu, Calif., and the Denver Research Institute.

The first phase of the program involved a comparison of the performance of an image-orthicon camera and a conventional film recording camera in a tracking situation. A second film camera, which operated in synchronism with the tracking camera, recorded the TV picture being presented on one of the monitors. The two filmed records thus provided a means of comparing the performance of the two systems.

Early Tests

These first tests disclosed a rather startling fact. The poorer resolution of the TV system, as compared to the 70mm film used in the recording cameras, proved to be an advantage when the test aircraft disappeared from view because of small size. When the image became so small that it disappeared in the graininess of the film taken by the direct recording camera, it was still an identifiable spot on the TV pictures. Even though the optical image of a distant aircraft may have been smaller than the scanning beam spot of the camera tube, it would generate a video signal which could be seen on the monitor as a spot no smaller than the scanning beam of the kinescope. It would then disappear when its contrast became too low for it to be detected. This effective enlargement of a very small dot, coupled with the ability of the TV system to increase contrast and control the brightness of the reproduced picture, made it possible for a distant target aircraft to be identified more easily on the photographs taken of the TV monitor than on the films used in the direct recording camera.

Another advantage provided by the TV system was its ability to act as an infrared converter. The "haze-cutting" ability of infrared camera systems is well known, but in a tracking situation inferior performance might be expected from an infrared camera because a distant aerial object almost always appears darker than the sky. The use of an infrared filter has the effect of darkening the sky, thus reducing the contrast of the object. A blue filter theoretically would increase this contrast,[1] and this was found to be true for distances up to about 10 miles on clear days. Beyond that distance, or in haze, the contrast of the object is diluted by the light reflected and refracted by the atmosphere which is between the observer and the object. Since most of this dilution occurs toward the blue end of the spectrum, an infrared filter does provide an advantage at the greater distances.

In tests conducted at the U.S. Navy Air Missile Test Center during the early part of 1955, target aircraft were tracked with an image-orthicon TV camera, using a 60-cm lens and a Wratten No. 88A infrared filter, an average distance 47% greater than was possible with a theodolite camera, and 11% further than the theodolite operators could track visually.

However, the Navy Air Missile Test Center had specified that a 50% increase in range over that usually obtained by the theodolite operators was desired. The increased cost and complexity which the TV system would add to the tracking equipment could not be justified for a lesser improvement. The next phase of the program, therefore, was concerned with determining what the parameters of a TV system should be to obtain maximum tracking performance.

The fundamental problem to be considered was this: loss of object contrast is the principal limitation on optical tracking range. Generally, theodolite operators are free to use lenses of sufficient focal length to guarantee that aerial objects are not lost because of small size. The objects then disappear from view when their contrast becomes so diluted by the atmosphere that they can no longer be discerned.[2] Disregarding for the moment the effect of infrared filters, the question is, would it be possible for a TV system to detect a contrast level that is too low for the human eye to detect? If so, a considerable increase in tracking range could be expected, since the object contrast diminishes very slowly at great distances.

The work of Albert Rose of David Sarnoff Research Center, Princeton, N.J.,[3] provides a theoretical answer to that question. For the purpose of comparing television, the light-adapted human eye and photographic film, Rose derived a formula for determining the minimum brightness at which a test object could be perceived by any visual process:

$$\beta = 5\,\frac{k^2}{D^2 t\Theta}\,\frac{1}{\alpha^2 C^2} \times 10^{-3}\ \text{ft-L}$$

Where:

- β = scene brightness;
- k = threshold signal-to-noise ratio (in the primary photo process);
- D = diameter of the lens (in inches);
- t = exposure time (in seconds);
- Θ = quantum yield ($\Theta = 1$ means 100% quantum efficiency);
- α = angular size of the test object (in minutes of arc); and
- C = percent contrast of the test object.

Rearranging the equation, we obtain an expression for minimum discernible contrast:

$$C = \sqrt{\frac{5k^2 \times 10^{-3}}{D^2 t\Theta\alpha^2\beta}}$$

With such an equation, it might be possible to determine in what respects a TV system would be superior to the human eye system. First of all, it may be assumed that lenses of identical magnifying power would be used for both the TV system and the human eye. Thus, the object size, α, may be considered equal for both systems and likewise, the brightness, β.

However, the lens diameter, D, deserves some comment. As brightness increases, the human eye accommodates itself by automatically reducing its iris opening. Since one has external

Presented on October 7, 1957, at the Society's Convention at Philadelphia by Howard L. Roberts, Denver Research Institute, University of Denver, University Park, Denver 10, Colo. (This paper was received on September 12, 1957.)

control of the iris opening of the TV system, there may be an advantage here, provided of course that other parts of the video signal processing system do not overload.

The exposure time, t, of the eye is variously estimated as from 0.1 to 0.2 sec. The exposure time of the conventional TV system is 1/30 sec, as a result of the usual frame rate. The various devices so far proposed for reducing the frame rate to 10 or 15 per sec without causing flicker or image smear are complex and expensive. For the moment, then, it may be assumed that the eye has the advantage in respect to exposure time, although this subject has by no means been exhausted.

With regard to the threshold signal-to-noise ratio, k, authorities estimate a range from 2 to 7 for the human eye. Dr. Rose estimates k to be 5 and surmises that the "gain" mechanism of the eye keeps the noise level below a detectable magnitude. Thus, "signals" which are of the same magnitude as the "noise" in the eye will not be detected. This is not true of the TV system where the gain can be externally controlled.

The noise visible in the conventional system is not, however, due to the primary photo process, but to other sources such as scanning beam or amplifier noise (the exception to this is the image dissector which suffers in this comparison because of its extremely short exposure time). In present camera chains, system noise is considerably greater than the noise in the primary photo process. It was the scanning beam noise which limited the performance of the original TV tracking system, as the maximum range was reached when the object image became submerged in the noise visible on the monitor. The human eye has the big advantage here, but this is one area in which the TV tracking performance can be considerably improved.

The quantity Θ, the last to be considered, is one of considerable importance. Dr. Rose has estimated the value of Θ for the eye to be about 0.005 at high brightnesses and 0.05 at low light levels. Present-day image orthicons have photocathodes with a quantum yield of about 0.1, and values of as high as 0.3 for some photoemissive surfaces have been reported.[4] Some photoconductive surfaces have quantum yields of as high as 1.0 (or 100%), a figure reported by RCA for the "solid" Sb_2S_3 surface.[5] Herein lies the principal basis for believing that a TV system might be designed which could outperform the human eye in a tracking situation. Admittedly, such a theoretical discussion as this does not include all of the various subtle factors that enter into the vision process, but it does furnish a basis for believing in eventual success.

System With Vidicon Tube

The high quantum yield of the "solid" Sb_2S_3 photocathode in a vidicon tube was the basis for the development of a tracking system. Fortunately, tubes of this type, known as the RCA experimental type C73262, were available at the time. Without going into the many details involved in the development of the system, suffice it to say that the final system used a 300-scanning-line picture operating at 30 frames/sec without interlace, 300 lines being used to prevent overlapping of the camera tube's scanning beam, which would reduce the signal per line. Interlace was abandoned to insure even spacing of the lines. The video amplifier bandpass was restricted to 150 kc at the low end and to something less than 4 mc at the high end. It was necessary to restrict the low end of the passband to eliminate the shading which became apparent in the picture with the high amplification used, the shading being severe enough to overdrive the kinescope. The high end of the passband was restricted to eliminate the noise frequencies which are higher than the frequency necessary to reproduce the available image detail. (It had been found that the edges of objects viewed at great distances were blurred by atmospheric turbulence in conjunction with the image retentivity of the vidicon tube.)

With this camera chain, system noise was not the limiting factor on performance. An unlooked for source of "noise" caused trouble. This was the uneven character of the experimental vidicon photocathode, which normally is not visible in the picture, but under the conditions of high video amplification used here appeared as black and white spots which often masked the image of distant aircraft. These spots were caused by dark current variations throughout the photocathode. In addition, the considerable image lag of the experimental vidicon often caused loss of target if there was any quick movement in the theodolite.

In tests conducted at the U.S. Navy Air Missile Test Center in late 1955, the vidicon system described briefly here, also using an infrared filter, exceeded the range of a human tracker by only 10% on hazy days and obtained only 80% of the human tracker range on clear days. This performance is not as good as the original image orthicon system. A premium type 6326 Vidicon, which has a "smoother" photocathode and less image "lag," because of its lesser sensitivity did not perform as well as the experimental type.

Conclusions From Program

At this point, the program ran out of funds and an operational piece of equipment had not evolved from it. The program was halted to allow the "state of the art" to advance further. The "state of the art" has been advancing and it is now possible to conjecture about future developments. Since the performance of the vidicon system was limited by the characteristics of the pickup tube itself, a return to the image orthicon is indicated. Typical of the recent advances in pickup tube development are the new "multi-alkaline" photocathodes which are reported to be five times as sensitive in the infrared region as the presently available cesium-antimonide cathodes.[6] More refined manufacturing techniques can reduce the scanning beam noise also. The importance of preventing stray or reflected light from falling on the photocathode,[7] diluting the contrast of the image, cannot be overstressed so that attention paid to reducing the reflectivity of the many elements within the image orthicon could enhance tracking performance. It is possible also that a wide spacing between the glass target and the target-mesh would increase the contrast of small, faint objects because of the redistribution of secondary electrons on the glass target.

These considerations concern the pickup tube itself. In other areas, a determination of the optimum scanning parameters for the image orthicon is in order. The effect of proper passband shaping of the video amplifiers on signal-to-noise ratio has recently been demonstrated in systems designed to operate at low light levels and the application to a tracking system is straightforward.

Many other devices to improve the tracking performance have been suggested. It is believed that the possibilities have not been exhausted and that the performance of the original image-orthicon system can be greatly improved. Success in designing TV systems which outperform the human eye at low light levels supports the belief that a system can be built which can outperform the eye in low contrast detection at high light levels.

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3. Albert Rose, "The sensitivity performance of the human eye on an absolute scale," *Jour. Opt. Soc. Am., 38:* 196–208, Feb. 1948.
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5. Albert Rose, "An outline of some photoconductive processes," *RCA Review, 12:* 362–414, Sept. 1951.
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Discussion

Charles Shelton (Radio Corp. of America): While engaged in a similar project at White Sands Proving Ground we have come up with similar conclusions. We, too, were concerned about the reduction of contrast when infrared filtering was used. I have seen it used in some applications with apparently satisfactory results, but we found at White Sands that in most practical applications the object did appear white, because it was above most of the atmosphere. Since you were interested in objects at lower altitudes, would you comment?

Mr. Roberts: I've heard some disrespectful people at White Sands refer to Point Mugu as the best instrumented fog bank in the world. The Navy's test range is on the Pacific coast, about 60 miles from Los Angeles. There is a smog problem. Most of the missiles tested do not exceed the altitude that research missiles at White Sands obtain. At such altitudes over water, the object contrast is usually darker than the sky. If it could be made lighter than the sky, it would greatly lessen the problem of getting range.

Harry Sombor (Pathe Pictures): Did the target imperfections — what we refer to as orth spots — give you erroneous information in these tracking operations?

Mr. Roberts: No. We must have had very good tubes because the orth spots didn't bother us. We defocused slightly to insure that they were invisible.

K. L. Warthman (Bell Telephone Laboratories): Do you have any figures on resolution — comparison between the film and TV systems in lines per millimeter?

Mr. Roberts: I can only say that the TV system is inferior to the film that was used. The two slides shown with the paper were super XX, but in the tests at Point Mugu color film was used. The film evaluators found it slightly easier to determine objects on the color film than on black-and-white.

Mr. Warthman: Have you tried using landing lights in the daytime?

Mr. Roberts: That has been discussed but it is usually impossible or undesirable to hang lights on an operational vehicle. The vehicle comes out for tests and the range people have to fire it without adding anything extra.

Mr. Wartham: Have you tried putting lights on airplanes that you track?

Mr. Roberts: No, because our primary concern is with missiles.

Hugh Stewart (Radio Corp. of America): Have you considered the effect of focal length on your tracking result? You used, I believe, a 600-cm. lens.

Mr. Roberts: In the equation, it was taken into account by the object size, alpha. We found that the optimum focal length was a cut-and-try procedure — it should be just long enough to insure that the object disappears because of loss of contrast rather than small size. This, on the other hand, raises the problem of target acquisition in the near range. It would be possible to use one TV camera with a short-focal-length lens and one with a long focal length. The tracking operator would then have what amounts to an instantaneous change of lenses at any time that the video operator switched from one camera to the other.

Charles O. Probst (Cinefonics, Inc.): Was there consideration of the infrared radiations of the power plant itself? Presumably the jet or rocket power plant would be emitting radiations not visible to the eye that could aid the tracking with devices such as those used in infrared-seeking missiles. Aircraft hot metal radiation peaks in spectral distribution at about 3.5 μ with ample energy emitted at wavelengths either side of this peak. See article in *Astronautics*, p. 33, May 1958.

Mr. Roberts: It was given serious consideration. The problem is to find a TV tube which is sensitive to infrared radiations of that wavelength. The infrared region which we use is the one sometimes referred to as the near-infrared region, just beyond the visible wavelengths. It is my impression that most radiations from jet engines are at considerably longer wavelengths.

Airborne Closed-Loop Television System

By ARTHUR F. FLACCO

An airborne television system which utilizes the image orthicon was developed for the USAF for use in a high-performance aircraft. The system requirements are such that the more sensitive wide-spaced image-orthicon pickup tube is used with a nonstandard line and field rate.

This television link is designed to meet Air Force specifications, for a specific Air Force requirement. This system is not a modified commercial chain despite the fact that some of the circuit requirements are quite similar to those of studio cameras. Most major circuit components are not recognizable when compared to their commercial counterparts. Tubes are JAN or military types. All components are ruggedized and adapted to military use. Materials and workmanship meet the requirements of Air Force equipment. The system is capable of operating with one or two cameras. The units required for operation as a single camera system are the camera, synchronizer, monitor and power supply. For dual camera operation, a second camera and an auxiliary unit are required.

Presented on October 7, 1957, at the Society's Convention at Philadelphia by Arthur F. Flacco, Airborne Radar and Missile Engineering, Defense Electronic Products, Radio Corp. of America, Camden 2, N.J. An earlier version of this paper appears in the *Proceedings of the National Electronics Conference, Vol. 13.*

(This paper was received on November 13, 1957.)

Description

The system operates with approximately 25 ft of cable between the cameras and the synchronizer and 170 ft of cable from the synchronizer to the monitor. To meet operational requirements, the yokes in the cameras and monitors were rotated 90° so as to obtain a raster scanning from left to right in the field or slow scan, and bottom to top during line or fast scan. "Horizontal" then became "vertical" and vice versa. In order to avoid misunderstandings, the terms "line rate" and "field rate" are used where applicable.

The power provided for the system is 400-c, 120-v, 3-phase a-c from the ship's supply. The complete dual camera system requires about 3 kw of power at maximum load. Over one-third of this power is required for heating the two cameras when the coldest conditions prevail. Normal power consumption when heating is not required is approximately 1800 w.

Temperature, altitude, vibration and shock characteristics of MIL-E-5272A (specifications applicable to airborne equipment) are required. Operation is required at temperature extremes from +160 F to −76 F, altitudes above 50,000 ft, impact shocks up to 10 G for 20 msec and under vibrations from 5 to 500 cycles.

In addition to these requirements, no components are permitted to operate at a temperature that might ignite fuel used by the plane and no corona or arcing is permissible. Vibration effects were not permissible in the picture presented on the monitor.

Unit Description

Camera

The tube used is the "Wide-Spaced" Image Orthicon, designated thus because it has a 150-mil spacing between the glass target and mesh as compared to a 3-mil spacing in the image orthicon commonly used for commercial studio work. By increasing mesh-to-target spacing, target capacity is reduced. This effects improved vibration characteristics, reduced time lag, and most important, better signal-to-noise ratios at very low light levels.

The wide-spaced tube is capable of producing useful signal information at 1×10^{-5} ft-c on the photocathode. At 1×10^{-3} ft-L of scene brightness the wide-spaced image orthicon can reproduce more information than can be discerned by the dark-adapted human eye.

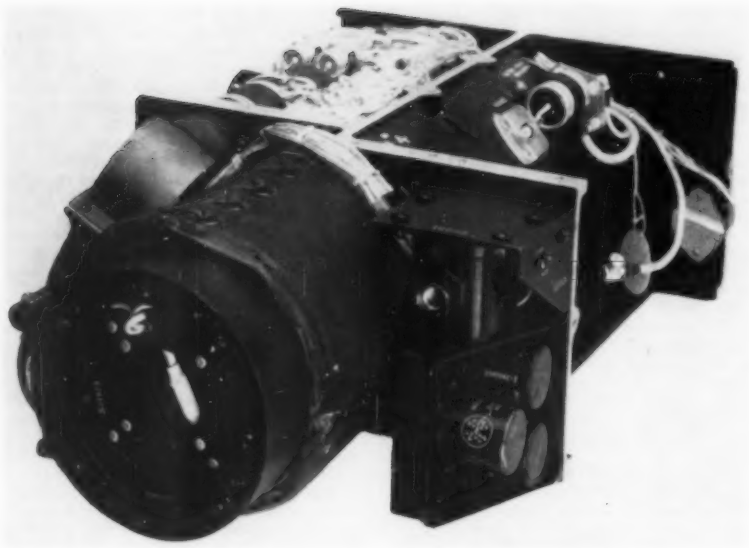

Fig. 1. Camera housing image orthicon. Camera contains preamplifier with voltage-regulated plate supply, dynode voltage dividers and heating and cooling system.

The camera housing the image orthicon (Fig. 1) contains a preamplifier, a voltage-regulated plate supply for the preamplifier, and the dynode voltage dividers. It also contains the heating and cooling system, which consists of a series of resistive heating elements in an internal forced-air system. This system maintains the image orthicon temperature within operating limits. In addition, the air stream is by-passed or recirculated in response to changes in the outside ambient temperature. At higher altitudes a barometric switch reduces the power in the convection heaters and heating is accomplished primarily by conduction through the camera housing. This system enables the camera to be brought to operating temperature within 20 minutes at any altitude from sea-level to over 50,000 ft.

Power Supply

The power supply unit (Fig. 2) provides all the d-c power needed to operate the system and includes some control circuits necessary to operate the camera.

Six volts d-c is provided for the filament of the image orthicon in one camera. Three regulated d-c supplies (+250, +150, −150 v d-c) are provided. A relay used in common with all three supplies causes them to go into operation after a time delay. This allows sufficient filament warm-up time to protect all tubes for approximately 54 sec before the plate supplies become available. The system also has a "standby" switch and an "emergency override" switch which by-passes the time delay and makes the plate supply voltages available immediately.

The power supply also contains a regulated focus current supply for one camera. A number of the controls necessary to adjust the camera are included in this unit. They are alignment controls, multifocus, image-orthicon gain, field size, and horizontal centering. A coaxial relay actuated from the control panel switches video from either camera to the monitor.

Monitor

The monitor (Fig. 3) contains a kinescope and associated circuitry which includes monitor line rate deflection, monitor and camera field-rate deflection, kinescope ultor-voltage, and a video amplifier.

Field-rate deflection is obtained by taking field-rate drive pulses from the synchronizer, and using them to trigger a field-rate deflection circuit. The circuit consists of a sawtooth generator, sawtooth amplifiers, and a power output tube which drives the field-rate yoke through the output transformer. Thermistors in series with the field-rate yoke compensate for temperature changes that would change the field-rate scanning.

Line-rate deflection is obtained through use of a reaction scan circuit from which an ultor voltage of 10 kv is obtained. A conventional damper diode prevents ringing in the line-rate sweep. The high voltage supply is regulated by means of a corona regulator tube.

The video signal obtained from the camera preamplifier is amplified in two stages, then d-c restored with a driven clamp. External mixed blanking obtained from the synchronizer is added to the video signal.

Synchronizer

The synchronizer (Fig. 4) generates the sync signals for the system. The field rate is 50 cycles with 2-to-1 interlace. The line rate is 625 lines/sec. The basic oscillator frequency is 31,250 cycles/sec, which when counted down in a 5:5:5:5 sequence yields the 50 cycles for the field rate. A divide-by-two stage provides 15,625 cycles for the line-rate drive and blanking signals. Other circuits in the synchronizer include most of the auxiliary circuits for one camera.

Auxiliary Unit

The units described comprise the equipment required for single camera operation. When using both cameras, an auxiliary unit is required. This unit contains the field-rate deflection circuits and most of the auxiliary circuits for the sec-

Fig. 2. Power supply unit for d-c power to operate the system.

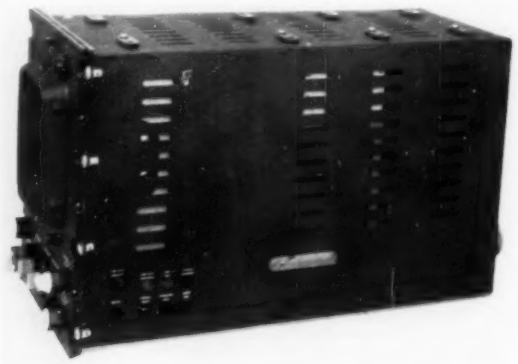

Fig. 3. Monitor containing kinescope and circuitry.

ond camera. Line-rate deflection is obtained, as noted above, from the synchronizer. During dual camera operation, the line-rate deflection yokes of both cameras are in parallel. When the second camera is removed it is necessary to substitute a dummy load consisting of an inductance simulating the second yoke.

System Performance

Because of schedule requirements it was not possible to thoroughly test engineering prototypes before this paper was written. It is expected that picture quality approximating that of studio equipment will be obtained at normal operating temperatures. At extremes in temperature some degradation is expected but it will probably be minimized through the use of the camera temperature-control system, feedback in deflection circuits, and the use of precision components in critical circuits.

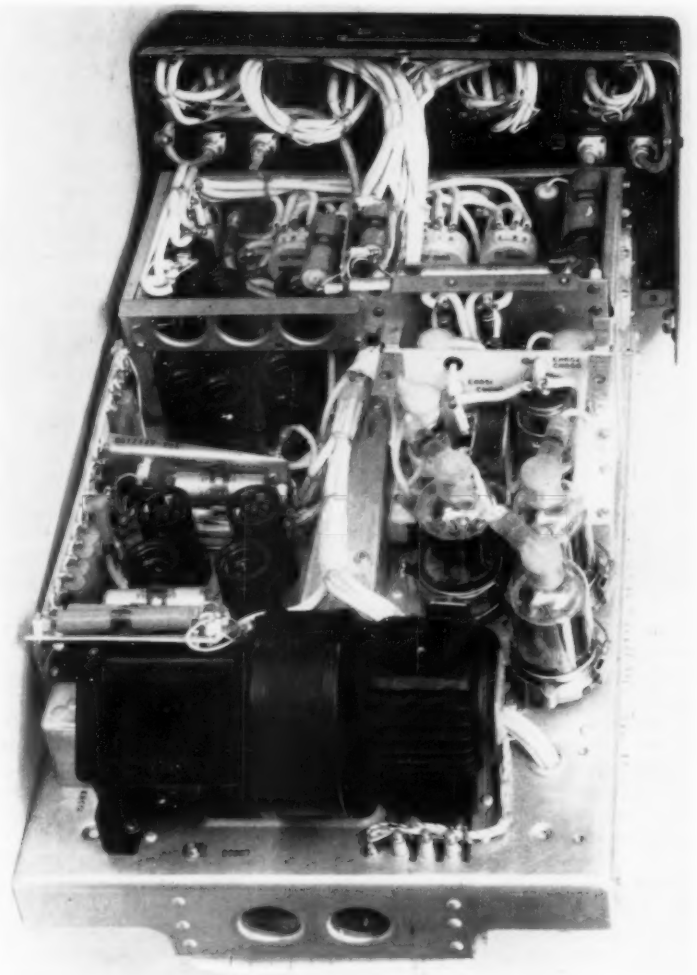

Fig. 4. Synchronizer generating sync signals for the system. Other circuits include auxiliary circuits for one camera.

Errata

A Directory for Members, April 1958, Part II:

On p. 9, change under **Papers,** *Europe*, GERMANY:
for: Hans J. Jost, Zerbster Str. 65, Berlin, Lichterlelche, Ost, Germany
read: Dr. Adolf Kochs, Bavaria-Filmkunst Ag, Schliessfach 9, Munich 9, Germany.

On p. 30, *for:* **Daily, C. R.,** Optical Eng., Paramount Pictures Corp.
read: ———, Hughes Aircraft Co., Research and Development Laboratories, Culver City, Calif.

On p. 36, *add:* **Haber, Jack,** Production Mgr. Mecca Film Labs. Mail: 1058 Cramer Ct., Baldwin, L.I., N.Y.

On p. 44, *for:* **Kreuzer, Barton,** Manager, Marketing, Astro-Electronic Products, Princeton, N.J. (F), *add* Radio Corp. of America.

On p. 48, *for*: **McGeary, Frank M.,** Pres., Motion Picture Laboratories, Inc. Mail: 1508 Pinewood St., Falls Church, Va. (M), *read:* ———, Mail: 1672 Union Ave., Memphis 4, Tenn. (M)

On p. 48, *for:* **Miller C. David,** Asst. Supvr., Eng. Research, Battelle Memorial Institute. Mail: 1511 Lincoln Rd., Columbus 12, Ohio. (M), *read:* ———, Cons. in Research and Development, 326 W. Fifth Ave., Columbus 1, Ohio. (M)

Progress Report, *Jour. SMPTE, 65:* 289–343, May 1958:

On p. 289, *The Committee: add* J. M. UNGER who was an active contributor to the report and was inadvertently omitted.

On p. 306, col. 1, para. 4; and Fig. 31: *Note* — The illustration presented as Fig. 31 is the Auto-Vac Model L, a vacuum forming machine of The Auto-Vac Company, 1984 State St. Extension, Bridgeport, Conn. This equipment, described as the largest vacuum forming machine ever made, has been used for making large sheets of fire-resistant plastic for studio set construction at the Columbia Broadcasting Studios.

On p. 322, col. 3, para. 3: *for:* The Industrial Vidicon Camera Channel Type BD835A . . ., *read:* The Industrial Vidicon Camera Channel Type BD-871. . . . (Figure 56 (p. 323) shows the BD835A which is earlier equipment not illustrative of the description on p. 322. The BD-871, as described on p. 322, is shown in the New Products column of this *Journal*, p. 510.)

Fig. 2. Power supply unit for d-c power to operate the system. Fig. 3. Monitor containing kinescope and circuitry.

A Machine for Cleaning Motion-Picture Film

By JOHN R. TURNER, STANLEY L. SCUDDER and EDWARD H. DEANE

A machine is described for the cleaning of motion-picture film by the spray application of water containing a detergent. Following the spray wash, rinse sprays and an Ott-type squeegee provide additional cleaning action prior to drying. The film is wet for such a short time that little moisture penetration occurs, and only a brief drying time is necessary. The film is not subjected to physical contact with wipers or buffers, nor are other scratch or abrasion hazards present on the machine. Surface deposits, loose dirt, and embedded dirt normally encountered on motion-picture film are effectively removed. Coatings of some alkali-soluble lacquer used on motion-picture film are effectively removed by the use of alkaline solutions in the sprays in place of the detergent solution. The results of experimental cleaning trials have shown this machine to be particularly satisfactory for color films. Black-and-white films may be subject to density losses when rewetted and dried more than 10 times.

In order to be satisfactory for projection, motion-picture prints and the negatives from which they are prepared must be free of dirt particles and deposits.

Dirt must be removed from motion-picture film with great care since permanent scratch damage may easily result from the cleaning operation. Both the emulsion layer and the support, although reasonably durable materials, must not be exposed to abrasive action because physical imperfections, which may be scarcely perceptible in a casual inspection of the film, are readily visible on projection.

The cleaning equipment to be described is the result of an effort to devise a means of obtaining adequate surface cleanliness without wiping or buffing and without other hazard to the film.

Conventional Methods of Cleaning Film

A solvent-wetted wiping cloth in the hands of a skilled operator constitutes the only widely accepted method for cleaning high quality motion-picture film. Film being cleaned is rewound slowly through the wiping stage and is inspected under critical viewing conditions. The solvent is renewed frequently, and fresh surfaces of the wiping cloth are presented sufficiently often to avoid any appreciable build-up of removed material, particularly abrasive particles. Unfortunately, this use of a fresh area of cloth may not be a sufficient precaution. A large abrasive particle can be picked up after cleaning as little as one foot of film. Some particles may even be present on a supposedly clean, freshly exposed surface of the cloth. Cleaning of areas adjacent to a cement splice is often particularly difficult and sometimes unsatisfactory unless it is done with extreme care.

Some film-cleaning machines employ a succession of rotary buffers running in contact with the emulsion and support surfaces of the film. Experience has shown that such machines often present severe scratch hazards. The use of this type of cleaning is only recommended for films that can be readily replaced, or where the presence of scratches is not objectionable.

In the past, carbon tetrachloride has been universally preferred for film cleaning because of its excellent solvent action for oil and grease, its rapid evaporation, its nonflammability, and its lack of any softening action on the support or emulsion layer. In more recent years realization of the severe toxicity of this solvent has precluded its further general use for the cleaning of film except under the most extreme safeguards.

Alternative solvents for this purpose have recently been evaluated by Fassett, Kolb and Weigel.[1] Unfortunately, none of these other solvents has as suitable a combination of cleaning properties as those associated with carbon tetrachloride. This circumstance, together with the fact that film cleaning has always been an exacting, time-consuming operation, has prompted efforts to obtain improved and more mechanized film-cleaning methods.

The same authors[1] also described the use of a brief detergent-solution treatment in an immersion-type film-processing machine for the cleaning of motion-picture film. A deterrent to the use of this method is the possibility of loss of, or damage to, highly valuable negative film if one of the many cement splices present in conformed negative should separate in a processing machine. Also, there is some danger of film damage during the full-length drying stage, which would be necessary as a result of the complete soaking that would occur during such immersion cleaning.

The method to be described is essentially the application of rapid processing methods to the detergent-cleaning of film as described by Fassett, et al.

Requirements for Rapid Cleaning by Detergent Solution

Requirements for a preferred film-cleaning system were outlined as follows:

(1) It must require no critical skill or extreme care on the part of the operator.

(2) There is to be no contact of the film with wiping cloths, pads or buffer rollers, nor are other abrasion hazards to be present during the cleaning process.

(3) No cleaning agents involving possible toxicity or fire hazards are to be used.

(4) The threadup is to be sufficiently short, and the design of the equipment is to be such that a splice failure will not result in the loss of film being cleaned.

(5) The operating speed of the equipment should exceed the cleaning rate by manual methods.

(6) No seriously detrimental physical or photographic effects to the film are permissible.

Principles of Cleaning Machine

Consideration of the above requirements suggested a trial of the spray application of a detergent solution at high velocity, followed by impingement drying before the aqueous solution had penetrated into the emulsion coating. It was anticipated that by short-time, intense, spray application of detergent solution and rinse water, the degree of wetting below the layer at which cleaning action was required could be minimized so that the subsequent drying stage could be very short.

Tests of this principle have shown that dirt normally present on motion-picture negative as a result of printing and handling can be effectively removed by such spray washing followed by rapid drying. A pneumatic squeegee applying high-velocity air is particularly valuable in this combination as an aid in removing any residual adherent material.

Description of Experimental Machine

The experimental machine constructed for the rapid, detergent-cleaning of motion-picture film is shown in Fig. 1. This equipment was satisfactory for experimental trials, but experience has shown that the component assemblies can be arranged more compactly, while in addition providing a somewhat improved performance.

Owing to the short threadup of this machine, the only film drive needed is a

Presented on April 29, 1956, at the Society's Convention at New York by John R. Turner (who read the paper), Stanley R. Scudder and Edward H. Deane, Color Technology Div., Eastman Kodak Co., Rochester 4, N.Y.

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positively driven, pull-through roller after drying. Drive is also supplied to the windup immediately following the pull-through. All other film rollers are free running idlers. The machine is shown schematically in Fig. 2.

Film travels from the supply roll through the detergent spray stage, which employs a pair of No. $\frac{1}{4}$-in P5010 spray nozzles* directed at a 30° impingement angle against the direction of motion of the film. The detergent solution is discharged at a rate of 1 gal/min from these nozzles at a pressure of 35 lb/sq in. The spray is contained within a closed chamber from which the applied liquid drains back to the recirculation tank. The remainder of the recirculation system consists of a pump, filter, and piping to the spray nozzles. No temperature control was provided on this machine since operation for extended periods was not intended; hence, the heating due to pumping was of little consequence. It was found in these experiments that the heat rise due to pumping raised the solution temperature to about 85 F in a room at 70 F. The 85 F temperature was particularly suitable for normal film cleaning on this machine. An additional pair of sprays might give increased cleaning action without appreciably deeper wetting.

Following detergent application, the film passes through a spray rinse, which consists of a pair of No. $\frac{1}{8}$-in. K-1 spray nozzles* directed at an angle of 60° to the film against the direction of film travel. Clean rinse water is supplied at 15-lb/sq in. pressure. This stage is less essential but it adds a further surface-scouring action and serves to remove the bulk of the detergent. The waste wash water runs to a drain.

Film passes from the rinse stage through a pneumatic squeegee of the type described by Ott,[2] which removes essentially all surface liquid along with residual surface dirt loosened but not previously dislodged by the sprays. The squeegee is carefully baffled to avoid spray of droplets onto the subsequent film path. Squeegee air must, of course, be free of oil, dust, or other objectionable contamination. Droplets deposited on the emulsion surface after squeegeeing and prior to drying will result in pock marks due to delayed drying of these spots. Adequate exhaust from the enclosure just ahead of the squeegee is helpful to prevent a pressure build-up that would tend to blow droplets onto the squeegeed film.

The final stage is a high-velocity, impingement dryer of the type described by Miller[3] with an effective path length of 48 in., a drying-air temperature of 100 F, and a static pressure of 2 in. of water, for an operating speed of 45 fpm on Eastman Color Negative Film, Type 5248. Other conditions involving greater moisture absorption may require additional drying.

*Supplied by Spraying Systems Co., 3201 Randolph St., Bellwood, Ill.

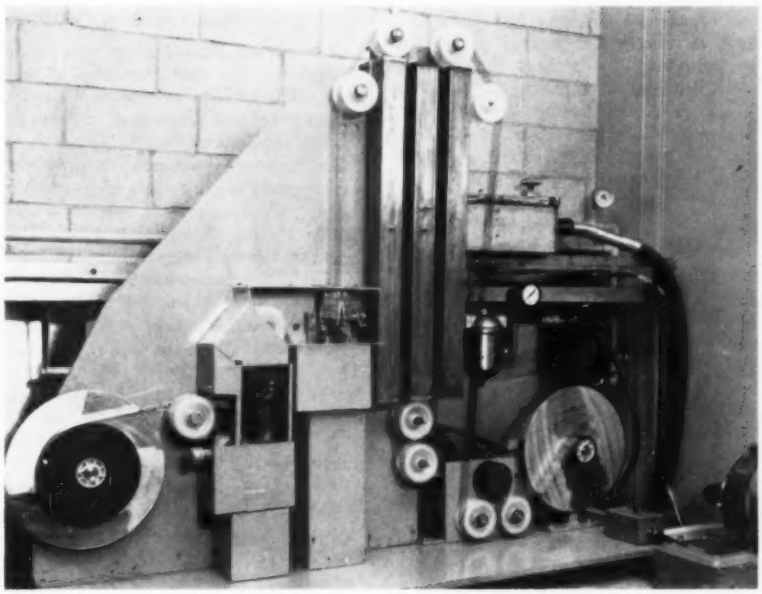

Fig. 1. Experimental machine for detergent-cleaning of film.

Through the entire film path, undercut film rollers with conical shoulders are used except at the pull-through, which is a cylindrical rubber roller making full contact with the support surface. Except for the pull-through, the only contact the film makes with a solid surface is along its edges at each roller. The rollers used are intended primarily for 35mm film, but are also provided with a center section suitable for 16mm film without the necessity of any adjustment to the machine. The pull-through roller, made of pure gum rubber of medium softness, is ground to a true cylindrical surface. A suitable surface roughness is provided to obtain sufficient friction against the film, and to avoid any tendency of the rubber surface to become glazed.

Operation of the Cleaning Machine

Preparatory to operation, the machine is threaded with leader, and the air heater

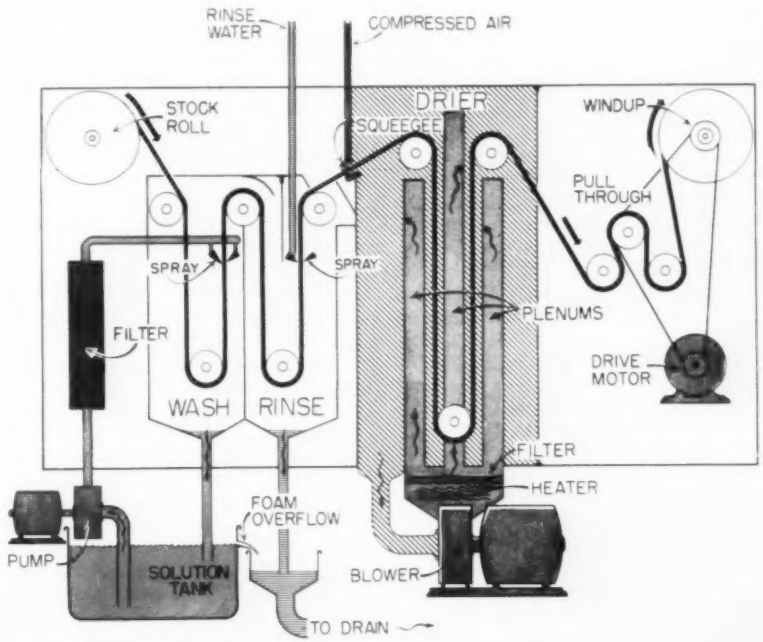

Fig. 2. Diagram of machine.

and blower are turned on for a sufficient time to obtain the desired drying-air temperature. The roll of film to be cleaned is loaded on the supply spindle. The outer end of the film is attached to the leader by means of a patch of adhesive tape. To commence operation, a master control is closed to turn on the detergent pump, rinse water, squeegee air, and film drive.

A check is made as the leading end of the film passes through each stage to make sure that the machine is operating normally. Film leaving the dryer is examined for dirt, scratches and adequacy of drying.

The machine should not be stopped except in an emergency, since additional soaking of the film in the spray stages will result in a larger amount of moisture absorption than can be removed with the drying capacity provided. Should such a stop occur, it would then be necessary to unthread the film from these stages, wipe off the surface liquid, and allow the film to reach sufficient dryness in room air.

It is convenient to have a sufficiently long trailer spliced to the end of the film being cleaned to maintain adequate tension on the final portion of the film or an elevator can be provided at the feed end to permit splicing-in without stopping the machine. An adhesive patch can be applied so quickly that only a small elevator would be needed. No elevator is strictly necessary at the windup end, although a single floating loop might offer some added operating convenience.

Raw-stock leader spliced to processed film to be cleaned presents some difficulty in drying on this type of machine. The more rapid moisture absorption of unprocessed emulsion coatings requires more drying after cleaning than is necessary for processed film. Under these conditions the film must be overdried in order to dry the leader sufficiently. The benefits obtainable through the use of detergent-cleaning would appear to warrant the slight additional cost of a leader stock that can be dried at least as rapidly as processed film.

Results Obtained in Experimental Trials

Experimental trials of this machine have been concerned with three separate applications:

(1) cleaning of normal negative or print films;

(2) cleaning of lacquered negative films; and

(3) removal of lacquer coatings from negative films.

The processes used and the results of these trials are not intended to imply specific recommendations for commercial film-cleaning operations in general. There are necessarily many types of film and many types of dirt on film requiring cleaning that could not be included in these experiments.

Cleaning of Normal Negative or Print Film

For normal film-cleaning, the spray application of a detergent solution such as a 0.1% solution of Kodak Photo-Flo Concentrate at a pressure of 35 lb/sq in. and a temperature of 85 F has been found to remove adherent particles and oil or grease smears up to and including heavy oily fingerprints. Grease pencil marks are not completely removed in one pass through the machine, since the design is intended for maximum efficiency for the type of removal necessary in routine cleaning. After several passes, grease pencil marks are usually removed. Deeply embedded dirt, or that carried in severe scratches, may not be completely removed. Cleaning at and adjacent to cement splices is considered to be quite satisfactory.

For maximum cleaning effectiveness, it is essential that sufficient spray pressure and adequately high solution temperature be maintained. Tests carried out with the 0.1% solution of Photo-Flo have shown that a temperature of at least 80 F should be maintained but that temperatures much above this value may not noticeably improve the effectiveness of cleaning. While lower spray pressures may be sufficient for the cleaning of some films, a spray pressure of 35 lb/sq in. is recommended in order to insure effective cleaning action.

Embedded dirt in the emulsion layer has been found to be very effectively removed by detergent-cleaning in this machine. A 1000-ft roll of processed Eastman Color Internegative Film, Type 7270, was used for a series of tests. The film before cleaning had deposits of emulsion and support particles embedded in the perforation areas of the emulsion surface. These deposits extended into the picture area and were present in lesser quantity entirely across the picture area. Efforts to clean this film with a solvent-wetted wiping cloth had failed completely. Test prints were made from the internegative before detergent-cleaning, and after one and two passes through the cleaning machine. It was judged from projection comparisons of these prints that approximately 90% of the embedded dirt was removed in the first cleaning and that practically all of the remaining dirt was removed after two cleanings.

It became apparent during these experiments that cleaning of the emulsion surface with water has two fundamental advantages that had not been entirely appreciated. One of these, the temporary softening of the gelatin due to water absorption, releases embedded foreign particles thus permitting apparently hopelessly dirty film to be cleaned surprisingly well. The other advantage is that fine scuff- and cinch-marks in the emulsion surface are smoothed over by rewetting and drying. It is actually possible, though by no means guaranteed, that an apparently hopelessly dirty film with minor emulsion scratches can be restored to an acceptable quality through one or more cleaning treatments on this machine.

Since detergent solutions with a highly effective cleaning action are likely to have pronounced foaming tendency, measures must be taken to prevent excessive accumulation of foam. This is accomplished by minimizing the turbulence except at the sprays, preventing bubbles from entering the recirculation system, using a recirculation tank having ample surface cross-sectional area, and by providing a foam overflow into the rinse-water run-off.

Use of Organic Solvents Instead of Water Solutions: Tests have been carried out using methyl chloroform in the cleaning machine in place of the water solution of detergent. The rinse nozzles were connected to the recirculation system so that both sets of nozzles were discharging methyl chloroform at a pressure of 30 lb/sq in. Film leaving the Ott squeegee following the rinse stage was entirely dry. It was necessary to provide local exhaust at the squeegee in order to prevent solvent vapors from reaching the room air.

The trials indicated that the very brief wetting time provided for detergent-cleaning would have to be extended for fully effective solvent cleaning. Accordingly a solvent dip stage was added ahead of the spray chambers to permit a soaking interval before spray application of the solvent. Under these conditions the solvent-cleaning was found to be highly satisfactory and actually more effective than the normal detergent-cleaning process for the removal of some heavy deposits of oil and grease. Solvent-cleaning was not as effective as detergent-cleaning for the removal of embedded dirt. Increasing the temperature of the detergent solution to 120 F resulted in a removal of heavy deposits of oil and grease comparable to that obtained by the solvent cleaning.

The work done on solvent-cleaning discussed here is considered to be inconclusive. Certain problems were apparent that will require further work before any definite conclusions as to spray cleaning with solvent can be given. Further work along these lines is contemplated. This work will be reported separately at a later date.

Effects of Repeated Cleaning: The effects of repeated cleaning using detergents have been investigated by running closed loops of test material containing many cement splices through the cleaning machine for as many as 500 complete sequences of washing and drying. This number was considered adequate to reveal any undesired effects since 150 cleanings is the maximum that might

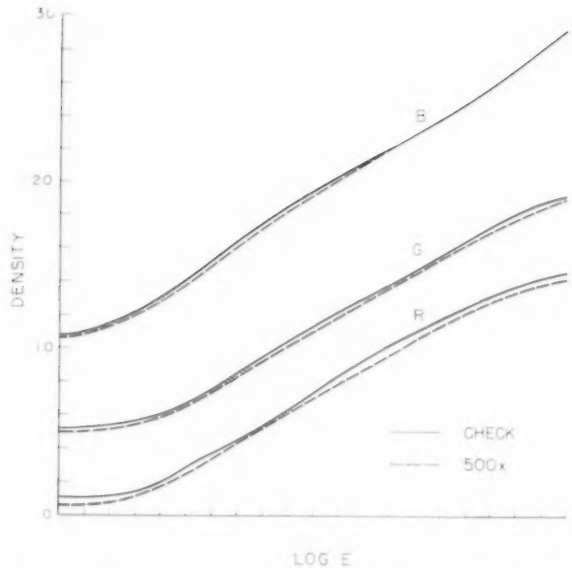

Fig. 3. Sensitometric curves of Type 5248 before and after 500 cleanings.

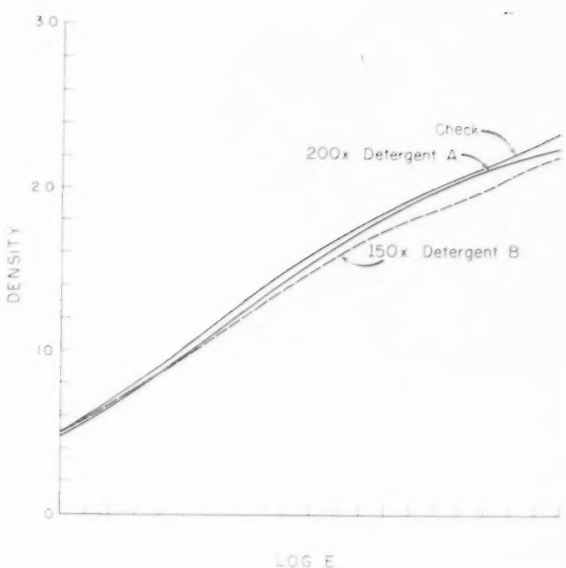

Fig. 4. Sensitometric curves of Type 5231 before and after repeated cleanings.

be expected for most motion-picture negatives in the course of a complete release printing.

Surface Gloss and Relief Image Effects: Considerable increases in surface gloss and relief image effects were noticeable on Eastman Color Negative Film, Type 5248, and on Eastman Plus-X Panchromatic Negative Film, Type 5231. These films were originally processed to a low surface-gloss. The increases in gloss and relief image are attributable to repeated impingement drying. This high gloss might be objectionable for contact-printing under conditions that might result in Newton's rings. Some negative film is processed to a high gloss. Lower gloss and reduced relief effects would result from a longer drying stage and a lower drying rate.

All of the original tests on the film-cleaning machine were carried out with an impingement dryer. Subsequent tests have been made employing conventional drying in a small cabinet of the type frequently used on continuous film-processing machines. This cabinet had a film threadup of 90 ft to give a two-minute drying time at a machine speed of 45 fpm. Drying conditions were: dry bulb temperature 80 F to 84 F, relative humidity from 35 to 50%, and air velocity of approximately 400 fpm. Multiple cleaning tests through this conventional dryer on Type 5248 showed that after 100 cleanings any change in surface gloss was so slight as to be barely detectable.

Density Effects on Color Film: No significant density changes resulted from 500 cleanings on Type 5248 (Fig. 3). A slight change in one layer was noticeable on Eastman Color Internegative Film, Type 5245, after 500 cleanings; after 150 cleanings the change in this film was scarcely detectable.

Tests made on some samples of Kodachrome films and on Eastman Reversal Color Print Film, Type 5269, showed that an increase in image contrast occurred as a result of repeated wetting and drying. The magnitude of the increase is much greater than would normally be acceptable. The effect is greater if impingement drying is used than is the case with a slower drying of the conventional type. Increases in contrast as a result of repeated wetting and drying of these films were noted even when water was used with no detergent.

Effects on Black-and-White Film: Repeated cleanings on this machine of Plus-X Film, Type 5231, or other black-and-white films, have resulted in density changes in the films. Figure 4 indicates the magnitude of such changes. The upper curve represents the densities of a sensitometric strip before cleaning. The middle curve shows corresponding densities of an identical strip after 200 cleanings with one detergent. The lower curve shows corresponding densities after 150 cleanings with another detergent. The largest change in density occurs in the maximum density, which may be reduced by as much as 0.16. This change is accompanied by a brownish discoloration of the image at the emulsion surface.

Print-through tests of sensitometric exposures of Type 5231 film, processed normally and then run through a rapid sequence of cleanings on this machine, have shown a density reduction after 100 cleanings roughly equivalent to an increase in printing exposure of 0.05 Log E over the entire density range when printed on Eastman Fine Grain Release Positive Film, Type 5302.

Cleaning tests on several types of black-and-white film have shown that under very carefully controlled conditions it is possible to use detergent-cleaning up to 50 times on the same piece of film without appreciable density loss or change in color of the silver image.

The mechanism of density changes associated with repeated wetting and drying is complex and is the result of changes in the structure of the silver grains.[4,5] The exact conditions that will result in a minimum change in density are difficult to specify for a given film type. On this machine, under general conditions previously found to result in no density change, moderate density changes have occurred associated with a small variability in the test conditions.

The density reduction found with conventional drying is usually about two-thirds of that associated with impingement drying, under the test conditions used.

Experience obtained thus far in the detergent-cleaning of black-and-white films indicates that a density reduction greater than permissible may be difficult to avoid in repeated cleaning. Black-and-white films should not be cleaned more than 10 times by these methods, unless density losses up to 0.16 are permissible at a density level of 2.00.

Physical Effects of Repeated Cleaning: Physical tests have been run on closed loops of test material for Type 5248 and Type 5231 films after a series of

Fig 5. Proposed design for cleaning machine.

cleaning treatments. The results of 500 cleaning treatments were as follows:

(1) Slight but measurable changes in shrinkage and curl occurred on both types of film. The magnitude of the changes was judged to be well within normal permissible limits for contact printing. The test conditions were considered to be severe since the film did not have time to reach moisture equilibrium after each drying.

(2) No change was detected in emulsion melting point, including that at the surface, for either type of film.

(3) No change was detected in image size, nor were any effects apparent at the edges of images for either type of film.

(4) Tests to determine any considerable changes in the abrasion resistance of the emulsion surface indicated no apparent difference for either type of film.

It is to be emphasized that these accelerated tests were carried out on film of recent manufacture that had received the recommended hardening treatment during processing. Film that had received other processing treatment, or had subsequently been subjected to conditions tending to alter the properties of the gelatin, might not be as unaffected by successive cleanings on this machine.

Effects on Dye Stability: Tests on Type 5248 film that had been treated in the recommended stabilizing bath (Kodak S-3) during processing showed no significant effect upon the dye images after 500 cleanings except for a gradual reduction in the effect of the S-3 treatment. Re-treatment with the S-3 bath after 500 cleanings restored the original stability. Similar tests on Type 5245 showed the same reduction in the effect of the previous S-3 treatment but at a more rapid rate. It appears from these tests that either of the films might be given frequent cleaning with a 0.1% solution of Photo-Flo without detrimental effect to the dye images, but if the films were to be stored for any appreciable time after cleaning, re-treatment with the S-3 bath would be a necessary precaution. Where negatives are being used for normal release printing, re-treatment with the S-3 bath might be advisable after from 10 to 20 detergent-cleanings on this machine. There is a possibility that a combined cleaning and stabilizing bath might be formulated. In this case no separate stabilization treatment would be required.

The stabilities of the dye images in Kodachrome films are affected unfavorably by the presence of Photo-Flo in the processed film. This wetting agent should not be used on Kodachrome films even for a rinse. Other detergents might be used for cleaning these films that would not affect the dye stability. Since the increases in contrast upon the repeated wetting and drying would be a problem in any case, it is judged that the cleaning of Kodachrome films and Type 5269 film by water solutions is not satisfactory for general use. Such cleaning might possibly be desirable for some specialized purposes where very few cleanings were involved.

Cleaning of Lacquered Film

Experimental cleaning with detergent solutions of the surfaces of motion-picture negative film that had been lacquered with Eastman Motion Picture Film Lacquers Type 231 or Type 238 gave relatively unsatisfactory results.

Since these lacquers must be removable by treatment with alkaline water solutions, a moderate permeability to water is a necessary property. Consequently, the intense spray application of highly effective cleaning agents on this machine causes a deterioration of the lacquer coatings.

The Type 231 Lacquer coatings have withstood from 10 to 20 cleanings before the appearance of small blisters. The Type 238 Lacquer is gradually reduced in thickness, being completely removed after 15 cleanings. Acidification of the cleaning solution is of only slight benefit in preventing this deterioration of the lacquer coatings.

A number of related factors in the cleaning of lacquered surfaces remain to be evaluated. Until more complete studies of the overall problem can be carried out, the detergent-cleaning of lacquered films on this machine is not recommended.

Removal of Lacquer Coatings

The film-cleaning machine has also been used for the removal of alkali-soluble lacquer coatings from motion-picture film, as would be required when these coatings have become worn after a period of use. For these tests the detergent solution was replaced by a 1% solution of sodium carbonate, or by the prebath solution (Kodak PB-2) used in the processing of Type 5248 film. The operating speed was 45 fpm.

The carbonate solution removes the Type 238 Lacquer coating completely from the film before the rinse stage. The prebath, it was hoped, would soften the lacquer coating but would allow it to remain on the film until the rinse stage, thus avoiding accumulation of lacquer in the removal solution. In these tests, reduction of the solution spray pressure to a minimum value was necessary in order to avoid stripping of the lacquer coating before the rinse stage. These tests have demonstrated that the machine is a very effective means of removing Type 238 Lacquer coatings.

Removal of the Type 231 Lacquer coatings was unsuccessful with either the prebath or the sodium carbonate solution. The use of a 0.25% ammonium hydroxide solution effected the complete removal of Type 231 Lacquer coatings. A fume exhaust would be necessary at the spray chamber and solution reservoir if ammonium hydroxide were to be used on this machine.

Treatment with an alkaline solution partially destroys the effect of the stabilizing solution (Kodak S-3) applied to Type 5248 film during processing. For this reason, re-treatment with S-3 solution is necessary after the removal of lacquer by this method. Restabilization might be carried out on the film-cleaning machine by the use of S-3 stabilizing bath in place of the cleaning solution.

Proposed Design of a Cleaning Machine

A proposed design for a detergent-spray, cleaning machine is shown in Fig. 5. The film rollers are mounted on the surface of the front panel of a stainless-steel cabinet. All auxiliary components such as pump, filter, supply tank, heaters and blower are mounted in rear compartments. The spray chambers, squeegee, and impingement plenums are also mounted on the panel surface. Each subassembly is readily removable.

The experimental model of the machine provided for about 2 ft of film between the squeegee and the dryer. This arrangement was convenient for inspection of the film prior to drying. It is now considered desirable to shorten this soaking-in period prior to drying to a minimum, and to place the squeegee as close to the entrance of the dryer as possible.

On the experimental model of the cleaning machine, the cleaning and rinsing spray boxes are shown just above bench height. It has been suggested that a more suitable position would be at, or a little below, eye level so that the film passing through the sprays would be more conveniently visible. This also permits a minimum length of film path between squeegee and dryer.

All parts of the machine beyond the squeegee jets are isolated from the room air by a transparent plastic enclosure covering the dryer, pull-through, and windup in order to prevent recontamination of the film after cleaning.

On the experimental model of the cleaning machine, a moderate but adequate film tension was maintained at all times to prevent the film from being deflected from its normal path in the detergent spray chamber. Similar machines built subsequently by others have employed a series of spray nozzles in order to obtain adequate cleaning at higher operating speeds. Under these conditions, a greater length of unsupported film results. At spray pressures sufficient for effective cleaning, the film may be deflected from its normal path unless an adequately high film tension is maintained. It is also essential that the spray nozzles be well aligned so that the forces from opposing nozzles will balance each other.

Less satisfactory film cleanliness was obtained with an open windup at the end of the machine. Even room conditions considered clean will permit some particles of surface dirt to be deposited on the film unless the film path from the dryer up to and including the windup is completely enclosed. The high degree of cleanliness obtainable from the cleaning machine makes the presence of dirt deposited at an open windup particularly noticeable.

Conclusions

The machine described has proved effective for some cleaning operations on motion-picture film. Dirt, oil and grease normally encountered on such film are removed to at least the same degree as might be expected from cleaning by a reasonably skillful operator using hand methods.

Some films are treated with lubricants or surface coatings of special composition such as silicones. Such coatings may not be effectively removed by the Kodak Photo-Flo solution used in these tests, but other detergents may be suitable. No tests have been made to establish this point.

While most of the hazards of other cleaning methods have been avoided, the use of this machine does require care in the selection of cleaning agents, and in the adjustment of conditions, particularly the insuring of suitable drying. No difficulty has been encountered with the failure of cement splices, provided that a splice is not already partially separated. It is essential that the squeegee effectively remove all surface liquid, particularly at splices, in order to obtain complete drying prior to windup.

Some film to be cleaned, either for printing or for projection, requires only the removal of loose surface dirt. A high-velocity pneumatic squeegee would give all the cleaning needed without the necessity of wetting the film. Such a cleaning unit would consist of a supply spindle, a pneumatic squeegee, a pull-through drive, and windup. If a dust-proof case were provided around the pull-through and windup assemblies and extending to the exit throat of the squeegee, this combination would be effective even though the room air were dust-laden. Since the presentation of this paper in April 1956, a cleaning machine of this type has been described in a paper[6] presented before this Society and published in the *Journal*.

Tests of the experimental cleaning machine described in this paper were planned with F. J. Kolb and E. M. Weigel of the Manufacturing Experiments Div. Eastman Kodak Co. They also made many helpful suggestions with regard to the cleaning processes. Results of the tests were interpreted by Kolb and Weigel, by C. E. Ives of the Research Laboratories, and by W. R. Weller and R. H. DeMoulin of the Color Technology Div. W. J. Knox, Jr. of the Research Laboratories supplied information on the properties of detergents used in the experiments. The proposed design was worked out by H. R. McNair, also of the Color Technology Div.

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Discussion

J. I. Crabtree (Eastman Kodak Co.): Speaking of the black-and-white film, have you made measurements of the swelling of the film in the detergent and the rinse bath? Does the addition, of say 10% alcohol reduce the swelling as it would certainly reduce the foaming? I would warn against using this treatment with nitrate film which has undergone incipient deterioration, otherwise you may not have any image at all because by virtue of the deterioration the gelatin becomes partially or almost completely soluble in water.

Mr. Turner: We have not tried out the addition of alcohol and we have not actually measured the swelling in the detergent bath. The time is so short that it would probably be very difficult to make any significant measurements of swelling in relation to moisture penetration. [We have since found that the addition of alcohol to detergent solutions for cleaning color films should be avoided because of the possible detrimental effects on some dye images of the combination of alcohol and detergents.]

John P. Byrne (Army Pictorial Center): Have you made any extensive tests regarding badly scratched negatives with resultant embedded dirt in connection with the soundtrack? Concentration so far seems to have been upon picture only and I'm just wondering if you possibly got a badly scratched composite negative, made a print before you used the detergent cleaning, and then compared that print with one from a detergent-cleaned negative. Did you try anything like that?

Mr. Turner: No. We have not yet dealt with badly scratched negatives or soundtrack.

Mr. Byrne: You're merely talking about picture — cleaning of picture film and not composite?

Mr. Turner: That is correct. We wouldn't expect to find a greatly different effect, however, on soundtrack.

Dana C. Rogers (now, Southwest Film Labs): Have you made any tests whatsoever with magnetic striping and was there any effect on the magnetic coating?

Mr. Turner: No, we've dealt with negative materials so far and have not examined the effects on magnetic striping.

Albert A. Duryea (Consolidated Film Industries): One of the types of dirt that we have found particularly difficult to remove in the lab is small shreds or dust of the film itself that come from the edges of the film when it is rewound against the flange from the edges. It's not greasy in nature; it's natural film dust scraped off the edges and is attracted to the film so strongly that it is quite difficult to remove. How do you feel that this machine would be in removing that kind of dirt?

Mr. Turner: It would probably remove it quite well, although I would want to make a specific test to be entirely sure. We have deliberately contaminated some film very badly after which it comes out entirely clean with one pass through the machine, but I just cannot be sure that all types of dirt would be as completely removed. [Subsequent tests have shown that the type of dirt referred to by Mr. Duryea is effectively removed by cleaning with detergent solutions.]

ABSTRACT

Siemens Dual-Strip 16/16 Projector With Synchronous Motor

By HEINZ KRONENBERGER

Dual-strip 35mm projectors carrying picture and sound on separate films have been in use for years in editing and production work. Siemens & Halske has had for some time a 16/8 dual-strip projector, consisting of their Model 2000 Projector with an additional film transport system for 8mm magnetic sound film. This is used chiefly by schools and industrial film makers for adding sound to silent films, as well as for supplying vernacular narration for foreign-language films.

Now Siemens & Halske has produced a 16/16 dual-strip projector which is intended to have particular application in the production of industrial films and TV commercials. Instead of 8mm magnetic sound film it uses 16mm film for the soundtrack. Studio operations are made somewhat simpler by having both picture and sound on the same size of film. Another important innovation is the provision of a 220-v, 50-cycle synchronous motor. This makes it possible to run the projector in synchronism with other recording or reproducing equipment.

In the table model, the regular drive motor is retained in addition to the synchronous motor, but it serves only to operate the air cooling system. The amplifier in the table model is the same as in the regular Model 2000 Projector, and can be used for reproducing either optical or magnetic tracks, separately or in synchronism. By attaching a magnetic recorder to the picture film side it is possible to run motion-picture film with either optical or magnetic soundtracks. A high-frequency oscillator mounted on the amplifier housing permits sound to be added in synchronism with the picture either on the edge of the picture film or in the center of the sound film.

A further development of this equipment is shown in Fig. 1. The 16/16 projector shown here is mounted on a stand which houses the amplifiers and additional related components designed to give it operational flexibility in many phases of 16mm studio work. Projection and sound systems are similar to those in the table model with the exception of a coupling between the synchronous motor and the cooling motor which allows the latter to be switched in as an auxiliary for additional power. This is done, for example, when the projector is used for re-recording with a pilot sound system. The film path on the second strip side of the projector is equipped with a ferrite erase head and combined record-reproduce head (Fig. 2).

Sound equipment and amplifiers are controlled from a panel built into the projector base. Pushbutton switches give a choice of reproduction from magnetic edge track, magnetic center track, or optical track; two additional buttons control recording on edge or center tracks. Output and input switches can thus be set to permit re-recording, e.g. from a separate magnetic soundtrack to a magnetic edge track on 16mm picture film.

The dual-strip projector and its allied equipment can be operated in line-frequency synchronism, by selsyn-type motor, or by cue interlock. Selection is made from a switch panel built into the projector stand (Fig. 3).

Another application of the projector is in conjunction with a vidicon TV camera. The camera can be attached in line with the optical axis of the projector and by means of a special lens attachment can be made to transmit film run through the projector. Film commercials can thus be run off on the projector and simultaneously viewed for effect on a TV receiver.

Abstracted from: "Studio-Zweibandprojektor 16/16 mit Synchronmotor," by Heinz Kronenberger, *Kino-Technik:* 45–48, Feb. 1957.

Fig. 1. 16/16 dual-strip floor model projector.

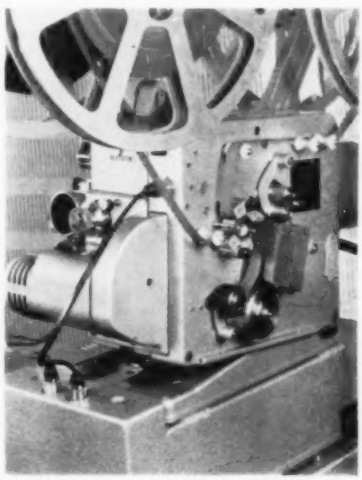

Fig. 2. Magnetic sound film system.

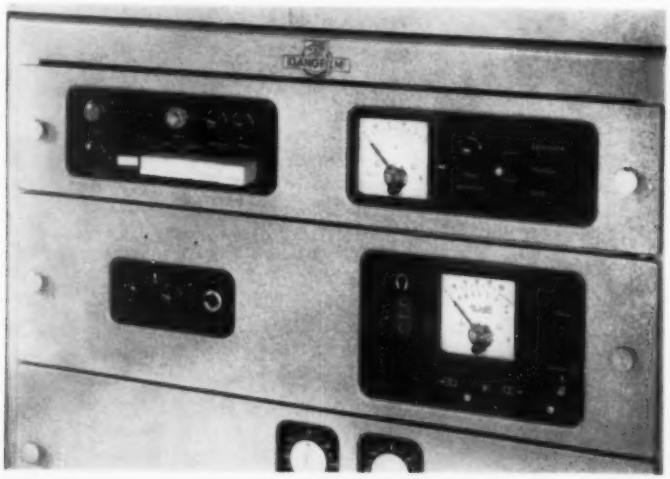

Fig. 3. Pilot sound system and other sync controls.

Letter to the Editor

16mm Professional Film—A Proposal

When a professional projector, such as that suggested by John A. Maurer in the February 1957 *Journal*, is available, I believe it should use a new professional 16mm film. This new film should be of such size and shape that it would not be used by the many nonprofessionals who habitually mistreat film.

Such a new film could look like that shown in Fig. 1 and add only 0.129 in. to the width of present double-perforated film.

With this format, the film could carry two soundtracks; in fact, with the discovery of the transparency of magnetic coatings, the new film could carry two magnetic and two optical tracks in the same space, one of each above the other. The added width of stock outside of the perforations would increase the strength of the film. Each magnetic stripe would act as a balance stripe to the other.

As surely as 16mm film took over many 35mm film formats, so will wide screen eventually come to 16mm. Having been intensely interested in wide-screen systems, I have been exploring ways to further a "growing up of 16mm." For wide-screen ratios, the problem is most flexible, in that any ratio desired may be adopted, standardized, or experimented with. For instance let us give our film a wide-frame line to start with; it will do no harm (Fig. 2).

Dimension A (height) remains the same for all wide-screen aspect ratios. I, personally, prefer 2 : 1 ratio like Todd-AO so the frame would look like Fig. 3.

To change the aspect ratio all one has to do is change dimension B (width). This system can utilize present pulldown mechanisms in both camera and projector without alteration, except for the addition of a tooth on the other side, which is for the better. Most camera and projector sprockets, idlers, and gates can be modified easily for the new film width.

And, not to ignore the application of the VistaVision principle to 16mm wide screen, it so happens that it works out so easily. Three 16mm frames in a horizontal manner work out to 2 : 1 nicely. Should other aspect ratios be more desirable, one has only to change the width and height of the aperture (Fig. 4).

Further thoughts on soundtracks which the new film size offers are: two optical 100mm tracks; two magnetic 100mm tracks; four magnetic 50mm tracks; two optical and two magnetic tracks, one over the other; two optical 100mm and four magnetic 50mm tracks. So multitrack sound could come to 16mm. Present 16mm subjects could be printed onto the new size of stock, the same as 65mm Todd-AO is printed onto 70mm film for release purpose.

October 29, 1957

R. Rees Lumley
215 Harding Pl.
Syracuse 5, N.Y.

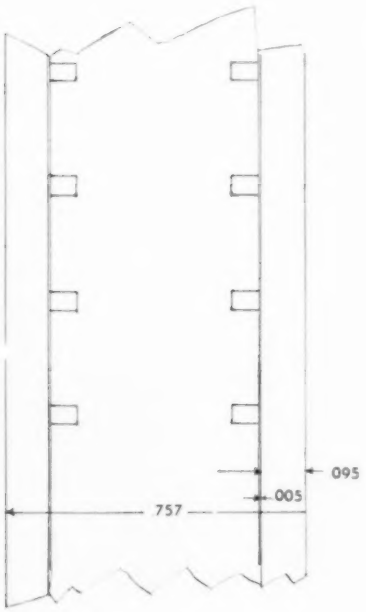

Figure 1

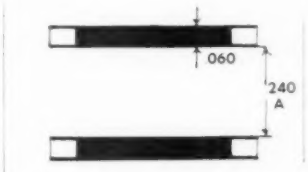

Figure 2

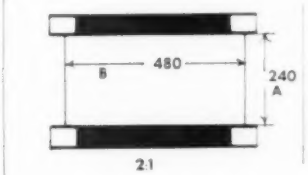

Figure 3

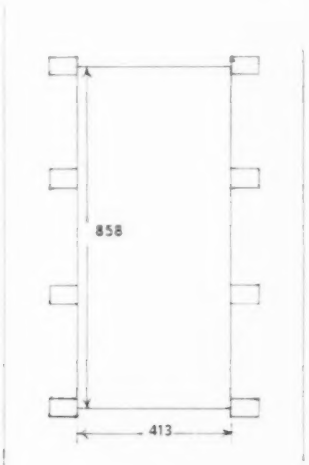

Figure 4

news and reports

84th Semiannual Convention, October 20—24, Hotel Sheraton-Cadillac, Detroit

Around the general theme of *Films and Television in Industry and Education*, intensive activity has already resulted in many scheduled papers.

The May *Journal*, pp. 344–346, listed the topics and the Topic Chairmen and their addresses. The June *Journal*, p. 415, carried additional information and the reminder to Topic Chairmen and to authors:

Deadline for Abstracts and Author Forms is for them to reach the Program Chairman by *August 4:*

C. E. Heppberger, SMPTE Program Chairman, 510 White Oak Dr., Naperville, Ill.

Copies of manuscripts are due the Program Chairman and Society Headquarters before *September 22*. Copies of papers may be reading copies, that is oral delivery drafts, or manuscripts subject to later revision. A final manuscript together with illustrations is, of course, preferable and is required for review by the Board of Editors for planning *Journal* publication.

Abstracts submitted after the deadline will be considered but such papers cannot be scheduled without special permission of the Program Chairman and Papers Committee Chairman. Acceptance of papers for the meeting does *not* imply acceptance for publication.

In addition to the Program Chairman and those chairmen listed in the May and June *Journals*, Society Headquarters is a source for information and Author Forms, etc., at any time.

A postal announcement of the sessions format, including Convention and Hotel registration forms will go to all members at the beginning of September; the September *Journal* will have the Advance Program with abstracts of all papers. Current schedules foreshadow a very substantial papers program at Detroit, with papers and demonstrations ranging from film printing to Eidophor large-screen projection systems. There are many papers on aspects of production and use of nontheatrical films in education and industry, films in television and television recording. There is a seminar on "16mm Color Intermediate Negative/Positives." Others sessions being arranged cover laboratory practices, instrumentation and high-speed photography, standardization, and TV studio and lighting practices.

Local Arrangements

The Local Arrangements Chairman, Jim Bostwick, has got together an excellent team of helpers for the myriad details and careful planning that go into a successful convention. It is many years since the Society organized a convention in Detroit and much that is by now comparatively routine in other convention centers is requiring extra attention from this group.

Local Arrangements Chairman: *James W. Bostwick*, General Motors Photographic

Exhibit: Raymond A. Balousek, Producers Color Service

Registration: Raymond A. Balousek and Kenneth M. Mason, Eastman Kodak Co.

Hotel Arrangements: Clifford Hanna, Video Films

Public Address and Recording: N. D. Reiss, Reiss Public Address Systems

Projection: John A. Campbell, Jam Handy Organization

Motion-Picture Shorts: Dana Manning, Jam Handy Organization

Hospitality: Sherman Willson, Wayne State University

Transportation: E. S. Purrington, Ford Motor Co. Photographic Dept.

Membership: Jerome Diebold, Wilding Picture Productions

Luncheon: T. P. Marker, Visual Presentations

Banquet: Michael Omalev, General Motors Photographic

Ladies Program: Mrs. James W. Bostwick, Mrs. Michael Omalev, Mrs. Raymond A. Balousek

Administrative Assistant: William B. McLaren, General Motors Photographic

Equipment Exhibit

As the center of the largest concentration of industrial, educational and TV film activity in the country, the Detroit area includes a great number of producers, cameramen and lab people who rarely, if ever, get the opportunity to see, except in advertisements, the new equipment that is being designed for their industry. For those in this area, the replacement or enlargement of their physical plant normally involves a trip either to New York or to Hollywood.

Plans are now all set at the Sheraton-Cadillac for installing the exhibit in an area that should surpass even the facilities at the Los Angeles convention for convenience. Located next to the auditorium where the technical sessions will be held, the exhibit will also be adjacent to the Registration area, so that access will be directly from the Registration Desk. Visitors will be able to enter or leave most sessions through the exhibit.

Unfortunately, the space available will not permit the installation of quite as many booths as there were at the Ambassador in Los Angeles, and it will therefore be more important than ever for companies wishing to exhibit equipment to get their booth orders in without delay. These should be sent directly to the Exhibit Committee Chairman: Raymond A. Balousek, Producers Color Service, 24 Custer, Detroit 2, Mich. Brochures and order forms have already gone out to former exhibitors and others; those who have not received this mailing and who nevertheless wish to reserve space should consult the floorplan on p. 489 of this issue and wire or write immediately to Ray Balousek, giving three choices of booths in order of preference.

The 83d Convention

A substantial and successful papers program, with emphasis on contemporary topics of vital interest to a variety of members, was organized by Program Chairman Herbert E. Farmer. The trend to earlier planning for programs has continued, with also increased emphasis on activities of Topic Chairmen which has been a prime interest of Papers Committee Chairman Ben Plakun. Regional Chairmen, however, remain very important for they supply a continuity of operations year after year.

For the 83rd Convention the Topic Chairmen were: Boyce Nemec, Closed-Circuit Television; Alan M. Gundelfinger, Cinematography; Frank Ralston, Distribution of Television Programs on Film; Robert M. Betty, High-Speed and Instrumentation Photography; John B. McCullough, Industry Milestones; Vaughn Shaner, Laboratory Practices; Petro Vlahos, Motion-Picture Studio Practices; James L. Pettus, Sound Recording; Ralph E. Lovell, Television Recordings; and Jack Kennedy, Television Studio Practices.

Among papers on popular and, in some

Charles Brackett, film writer and producer, Get-Together Luncheon speaker at the Society's Convention at Los Angeles, and Barton Kreuzer, SMPTE President. See addresses in June Journal.

EQUIPMENT EXHIBIT

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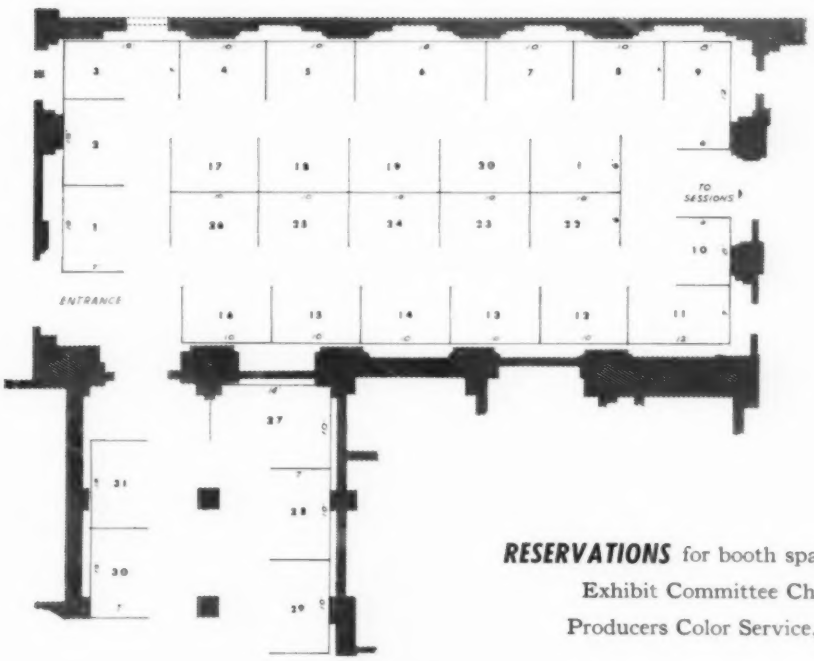
This first SMPTE equipment exhibit in the Detroit area will make it possible for industrial, educational and TV film makers and users to examine the newest developments in professional motion-picture and TV studio, lab and projection room equipment.



SPACE RENTAL RATES:

Booths 1, 2	$250
Booth 3	$300
Booths 4, 5	$250
Booth 6	$350
Booths 7, 8	$250
Booth 9	$325
Booth 10	$250
Booth 11	$325
Booths 12-16	$250
Booths 17-26	$225
Booth 27	$350
Booths 28-31	$250

RESERVATIONS for booth space are now being made by the Exhibit Committee Chairman: Raymond A. Balousek, Producers Color Service, 24 Custer, Detroit 2, Mich.

84TH SMPTE SEMIANNUAL CONVENTION

OCTOBER 20-24 / SHERATON-CADILLAC HOTEL / DETROIT

instances, controversial, subjects was a paper on "Subliminal Communication," presented during the session on The Past and the Future; and a paper on "Language Translation by Machine," by Max Kosarin, presented at the same session.

The Bryg System for television was described by Adolph Radzow during the session on Photographic Television Recording. This system is based on experiments on the human eye which have demonstrated that there is greater visual acuity and greater ability to resolve detail for black-and-white pictures than for pictures in color. A paper on "High Fidelity Video Recording," by Leo Levi, described a method of recording electronic signals at video frequencies on photographic materials by employing ultrasonic waves to modulate light intensity.

A session of unusual interest was conducted on two Stages of the M-G-M Studios, with an attendance so great that the audience was halved and each of the four papers presented twice. This was the Cinematography Session under Alan M. Gundelfinger. The dramatic developments and current problems in the wide-screen field were considered by authors and discussers with special qualifications.

Douglas Shearer demonstrated and explained the photographic systems and techniques used at M-G-M Studios in large-area negative photography. A paper on "Increased Depth of Field for Motion-Picture Photography," presented by Sidney Zipser, described a proposed method of achieving depth of field by means of a camera aperture pivoting on its own vertical center and accurately calibrated. Among the discussers was John R. Moore of Panavision, Inc., who contributed information about recent improvements in lenses and anamorphosing techniques.

W. E. Pohl described methods of processing and photography with large-area negatives at Technicolor Corp. and discussed techniques for producing anamorphosed and deanamorphosed prints from such negatives.

A paper by Brian O'Brien on "Conformal Printing System for Todd-AO Projection" described the system which compensates in a single printing step for projection keystone, for horizon curvature caused by the curved screen and for vertical line curvature due to barrel distortion introduced in extremely wide-angle lenses. The paper was followed by a lively discussion on questions raised by members of the audience on such points as flexibility in respect to theater presentation, splicing, etc.

A session on the timely subject of videotape recording treated in detail recent developments and trends. Seven papers were presented, five by representatives of Ampex Corp. Charles Ginsburg, presented a paper on "Interchangeability of Color Video-Tape Recordings." Other developments were described by Earl Roger Hibbard and Joseph Roizen. John M. Leslie, Jr., described engineering plans for further videotape development.

Robert A. Von Behren of Minnesota Mining and Mfg. Co. described special magnetic tapes and outlined their development. Jerome L. Grever of the Broadcast and Television Dept. of RCA described the recording of color television signals on 2-in. wide magnetic tape by an extension of the technique of recording television signals by high-speed transverse scanning of the tape. This session was organized by Ralph E. Lovell.

A Session on Industrial and Instrumentation Photography was organized by Robert M. Betty, to interest the average individual in instrumentation work as well as to acquaint the specialist with advances in the field. The Session included both technical papers and those of popular appeal. Among the latter were *Design for Destruction*, presented by Glenn E. Miller of the Motion-Picture Dept. of Lockheed Missile Div., and *X Minus 80 Days*, presented by Norman Jacobson of the Jet Propulsion Laboratories of Calif. Inst. of Technology.

Design for Destruction, a 35mm film in Technicolor, was shown as part of Mr. Miller's presentation. It traced the development of the instrumentation camera, with emphasis on immediate applications in missile testing and as a recording device in aircraft and satellites. *X Minus 80 Days*, a 16mm film, showed the development and firing of the first satellite launched by the United States.

Other papers included "A New Framing Camera," by Milton C. Kurtz of Beckman and Whitley Inc.; and, "Electrical and Optical Characteristics of an Ultra-High-Speed Electronic Camera," by R. Carroll

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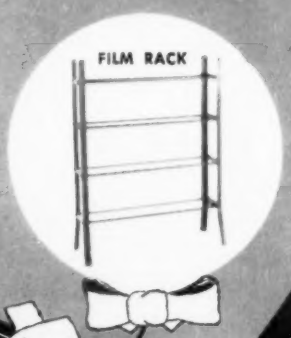
What The Well Dressed Editing Room Should Wear



EDITING TABLES & RACK:

HFC editing tables are made of strong angle iron construction with a bottom reel rack, formica table top, and 9" x 12" flush light well. Stock tables are 24" W x 60" L x 30½" H (ETBR-1) and 28" W x 60" L x 30½" H (ETBR-28). Any size can be made to the editors specification. The 4 tier table rack fits directly onto the back of the table and is ideal for holding small rolls of film for intercutting. (TR-1).

FILM RACK:

HFC angle iron film racks are inexpensive and especially made for 35mm 1000' reels or cans. Each tier holds up to 25 reels or cans. The entire rack can be taken apart and additional holes drilled to move the rods to positions for other reel sizes. Stock sizes are: 4 tier - AR-4, 5 tier - AR-5, 6 tier - AR-6, 7 tier - AR-7.

SWIVEL BASE:

HFC swivel bases enable the editor to turn the rewind to 2 additional positions for rewinding the film to be taken up from the editing machine or film bin in proper alignment. The rewind is attached onto the swivel base, which is bolted to the table (SB-1).

LEADER STANCHION:

HFC leader stanchions are attached to the HFC rewind and will hold 3 reels of leader or effects on top shaft front and one reel of leader on shaft in back facing the operator (LS-1)

FILM SYNCHRONIZER:

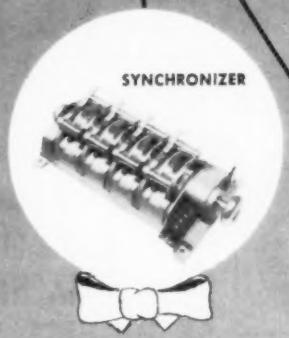
All types of synchronizers of 16 or 35mm are available from stock, as well as 16 & 35mm combinations; and 35 - 32 and 35mm combinations. Units to handle 55mm, 65mm and 70mm are available on special order.

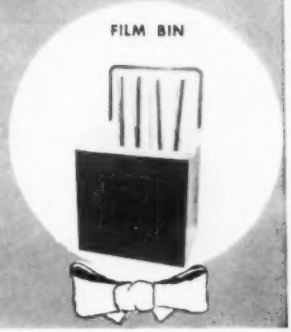
REWINDS:

HFC hand rewinds permit the operator to pull one or more reels with a minimum of effort. (RE—for normal winding, REF —with a top friction control, REL—with elbow brake and REU—with universal joint and end support). The outstanding features are: enclosed ball bearings, precision steel cut gears, interchangeable shafts, and a base which is cut at an angle to keep reels from moving up and down the shaft.

FILM BINS:

HFC steel film bins are available with hooks and casters. Trims are held on the hooks prior to matching. Film bin liners made of cotton drill are used on the inside of the bins to keep the film from being scratched or getting dirty. (SFB-1, 18" x 24" x 24"; LFB-1, 22" x 23" x 32")





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The plastics exhibit at symposium on April 25.

Part of the Equipment Exhibit at Los Angeles, April 21-25.

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Papers in which new techniques were discussed included "Image Illuminance and Irradiance With Carbon-Arc Image Furnaces," by M. R. Null and W. W. Lozier, National Carbon Co. Research Laboratories; "Fast Photography in High-Temperature Physics," by J. Gauger, W. Starr and V. Vali, Lockheed Aircraft Corp., Missile Systems Div.; "Photographic Techniques Applied to Recording Supersonic Track-Sled Shockwave Formations," by Neil Krenzel, U.S. Naval Ordnance Test Station, China Lake, Calif.; and "Color Exposure for High-Speed Photography of Some Self-Luminous Events," by K. H. Lohse, Edgar C. Bain Laboratory for Fundamental Research, U.S. Steel Corp. Research Center.

Plastics for the Motion-Picture and Television Industries was a Symposium sponsored jointly by the SMPTE and the Southern California Society of Plastics Engineers. Two papers were presented, followed by a Panel Discussion on Plastics for Sets and Props. The first paper, "Primer on Plastics," described the development of the plastics industry and the basic character and type of plastics useful to the motion-picture and television industries. It was presented by John Delmonte and William J. Dewar, Furane Plastics Inc., Los Angeles. The second paper, "Plastics for Motion-Picture Laboratories," by Roderick T. Ryan, Eastman Kodak Co., Hollywood, described plastics used in motion-picture film processing, such as rigid polyvinyl chloride which is used as sheets, pipes and joining members. Other plastics, used in processing include nylon rollers and butyrate film reels as well as reinforced polyester in tanks for holding photochemical solutions.

Organizer of the Plastics Session and Moderator of the Panel Discussion was Herbert Meyer of the Motion Picture Research Council. Panel members were: D. H. Bryan, Mobay Chemical Co.; Elbert Davis, PlasKem Corp.; Mr. Dewar; Robert J. Luskin, Goodyear Tire and Rubber Co.; A. A. Ray, Ray Products Co.; Barton H. Thompson, Molded Products Co.; and Erven White, Thalco.

Among topics covered in the discussion were: polyester resins — types, curing systems and reinforcing; epoxy resins — methods and properties of cured casts; types and functions of nonfibrous fillers and additives; weathering of polyester and epoxy fabricates; causes and prevention of warpage; colorless, transparent casting resins; principles and types of flame retardants; nature and function of release agents; spray equipment; hot melts; flexible and rigid molds; heat formable plastic sheets; foamed plastics; and ornamental and functional coatings.

The Symposium was enhanced by an exhibit of plastic props and structural units made in studio shops, including glasses and bottles (to be realistically shattered in Western saloons), guns, trees, gongs, flowers, spears and pillars.

The Distribution of TV Programs on Film Session, organized by Frank Ralston, was a very full one. It was held at the ABC Television Center, with the host providing a tour of the network and local film facilities in ABC's new Technical Building.

Especially helpful in putting on the sessions were Ted Fogelman who was in charge of motion-picture short subjects; Jack Hessick and Sam J. Aspaas who were responsible for projection; and Kenneth

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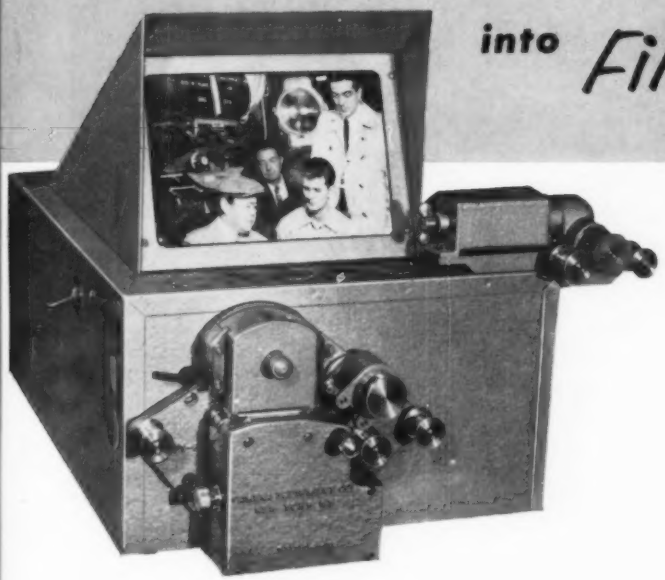

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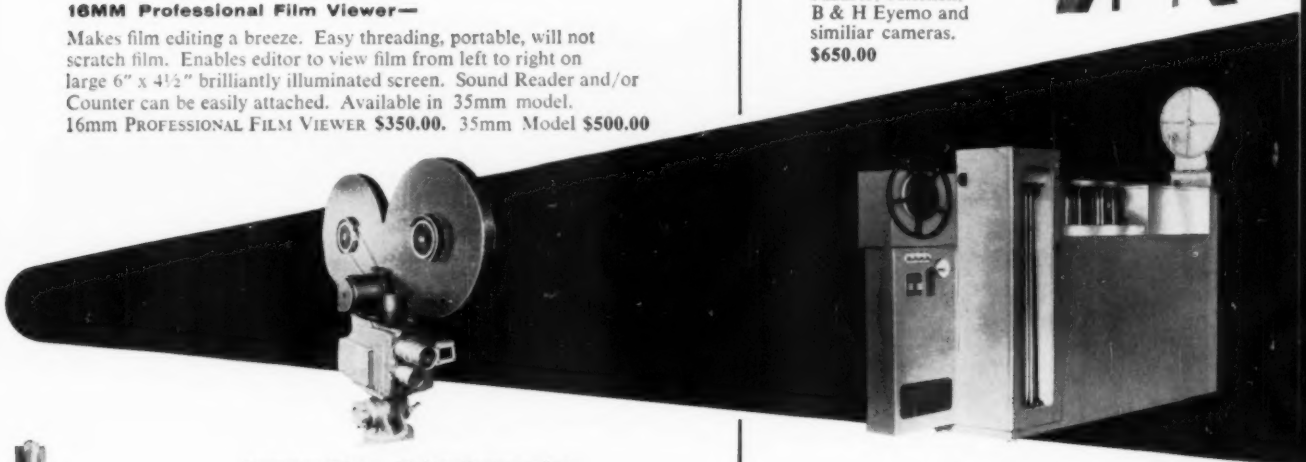

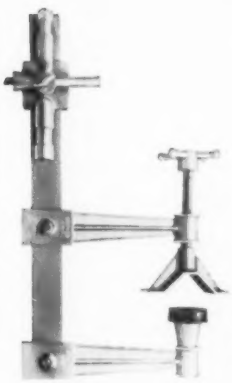

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Miura and Daniel H. Wiegand who attended to the public address systems and recorded the extensive discussions.

Equipment Exhibit at Los Angeles

For what was without doubt one of the most successful equipment exhibits the Society has ever organized SMPTE is greatly indebted to John Olsson, of Houston Fearless in Los Angeles, the Exhibit Chairman. John did a magnificent job in organizing the available space and in attracting some of the most interesting displays of new equipment that it has ever been our pleasure to see at an SMPTE convention.

Credit is due also to the Exhibitors' Committee, whose establishment last year gave the Society this time the benefit of help from the exhibitors themselves in laying the groundwork for a successful show. This help was effective in setting up a schedule of announcements to Sustaining Members and prospects; specific suggestions from the Committee also led to a full-page announcement in the January *Journal* and, most important, to the preparation of an Exhibit Directory, listing the items to be displayed at the various booths, which was mailed to all Society members and *Journal* subscribers in the U.S. and Canada before the convention. The Directory proved invaluable at the Convention, too, as a guide to the Exhibit. It will undoubtedly be repeated at future exhibits.

Every available booth was reserved well ahead of time, and there was even considerable competition for the last one, which in the end was shared by two companies. The location of the exhibit room, next to the auditorium where the technical sessions were held, helped keep the flow of visitors at maximum volume, and an experimental evening opening, at a time when no technical session was in progress, proved such an outstanding success from the point of view of attendance that it took the harassed guards almost an hour to clear the room in order to close.

Participating companies, whose displays of high-quality equipment contributed to the success of this fine show, were:

Animation Equipment Corp.
Associated Industries
Bell & Howell Co.
Berndt-Bach, Inc
Birns & Sawyer Cine Equipment Co.
Camera Equipment Co.
Andre Debrie Manufacturing Corp.
Electromation Corp. (Kinevox)
Electronic Systems of Illinois, Inc.
Encyclopaedia Britannica, Inc.
Great Books of the Western World
Harwald Co.
Karl Heitz, Inc.
Frank Herrnfeld Engineering Corp.
Hollywood Film Co.
Houston Fearless Corp.
Kling Photo Corp.
Lipsner Smith Corp.
Magnasync Mfg Co.
Magna-Tech Electronic Co.
Magnetic Sound Camera Corp.
Mole-Richardson Co.
Motion Picture Printing Equipment Co.
Moviola Mfg. Co.
Pembrex Theatre Supply Co.
Photo-Sonics, Inc.
Precision Laboratories
Prestoseal Manufacturing Corp.
RCA Film Recording
Reevesound Co.
SOS Cinema Supply Corp.
Strong Electric Corp.
Studio Supply Co.
Traid Corp.
Unicorn Engineering Corp.
W. M. Welch Manufacturing Co.
Westrex Corp.
Wollensak Optical Co.

Education, Industry News

The Society of Photographic Scientists and Engineers will hold its annual Convention, October 6–8, 1958, at the Manger Hotel, Rochester, N. Y. Program plans include a special group of papers on subjects related to the International Geophysical Year. Program Chairman is Jerome S. Goldhammer, CBS Research Laboratories, 485 Madison Ave., New York 22. Conference Coordinator is Ira R. Kohlman, Technicolor New York Corp., 533 W. 57 St., New York 19. Approximately 35 exhibitors are expected to display photographic equipment and developments during the Convention. Exhibits Chairman is Richard Van Steenburgh, Fairchild Camera and Instrument Corp., Robins Lane, Syosset, L. I., N. Y.

The SPSE was formed in December 1956 (*Journal*, p. 266, Apr. 1958). The membership is comprised of members of the former Society of Photographic Engineers and some members of the former Technical Division of the Photographic Society of America. The SPSE Conventions are held annually. This year's choice of Rochester for a meeting place is a particularly happy one. Among the informal activities to be enjoyed during the Convention are visits to George Eastman House and other famous photographic landmarks.—*Frank Smith.*

The furor created by the Bernstein Report on the motion-picture industry has somewhat subsided since its release early last April, but frequent comments in the columns of trade papers indicate that it is by no means forgotten. The 78-page document was based on statistics gathered and corre-

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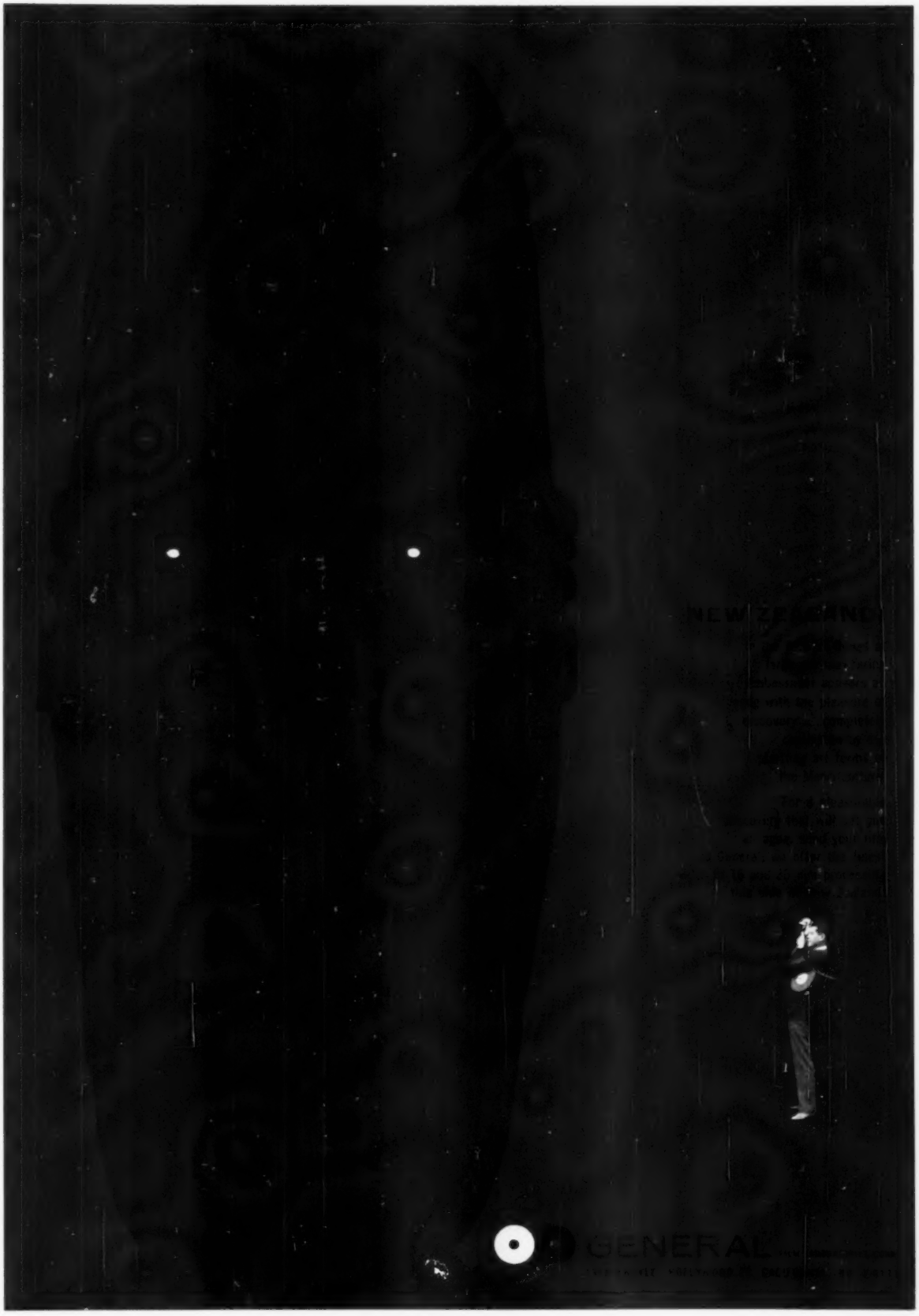

The new, easy way to lip-synched filming.

lated by Irving Bernstein, Associate Research Historian of the Institute of Industrial Relations, Univ. of Calif., Los Angeles, for the Hollywood American Federation of Labor. Copies were distributed to labor organizations and industry officials.

Dr. Bernstein drew only one conclusion: the motion-picture industry as it was in 1946 is "gone forever." The picture implicit in the report was sufficiently gloomy to bring screams of anguish and denial from industry spokesmen throughout the nation. One lesson seen by the *Film Daily* (Apr. 11, 1958) is that it is impossible to refute statistically this or any similar document. "If there is any one thing the (Bernstein Report) does point up, it is the industry's deficiency in the area of trade statistics. . . ," it stated.

A letter by the AFL Film Council which accompanied the report suggested a four-point plan to save the industry "from further deterioration." One of the most controversial of the Council's suggestions was for "an American countermeasure which would operate like the British Eady plan. . ." Adoption of this plan would mean that motion-picture production would be partially subsidized by the government.

The report takes into account the influence of television on the motion-picture industry, especially "the great imponderable of the future, the impact of television and most particularly the impact of toll TV."

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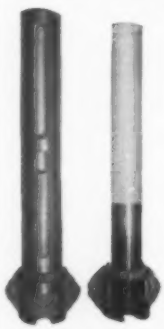

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The Institute of Film Techniques, City College, New York, will offer 15 evening-session courses during the fall term. Courses in photography, screen writing, sound and film editing, directing and production are offered. Elementary classes are open to amateurs and advanced courses are provided for professionals. Registration will be held September 8–11, 6 to 8:30 P.M., in Shepard Hall, 139 St. and Convent Ave., New York.

Adult Education Groups and Audio-Visual Techniques has been issued by the Clearing House of the Department of Mass Communications of Unesco. This is No. 25 in the series of Reports and Papers on Mass Communication compiled to help adult education groups solve problems arising from the increasing use of audio-visual media. The report is divided into five chapters: A Pedagogical Method for Adults; Group Life; The Group and Its Implements — Audio-Visual Techniques; Group Discussion; Checking of Results. It is available from Unesco Publications Center, 152 W. 42 St., New York 36, at a price of 75 cents. Among earlier reports still available are "World Film Directory — Agencies Concerned With Educational, Scientific and Cultural Film, "available without charge upon request;" Catalogue of Short Films and Film Strips," "International Rules for the Cataloging of Educational, Scientific and Cultural Films," and "Television and Tele-Clubs in Rural Communities." Each of these is priced at 40 cents.

Le Merle (**The Blackbird**), a film by Norman McLaren of the National Film Board of Canada, was the prize winner for the best utilization of color in the Short Films Competition of the World Film Festival at Brussels. It was also given particular mention for its qualities of humor and imagination expressed with a great simplicity of means. We have obtained the following description from the Film Board:

Le Merle is based on a well-known, old French-Canadian folksong. It is a cumulative nonsense song about a bird, which, with each verse, loses a different part of its body. . .but no sooner is a part lost than it reappears threefold; and, as the song progresses, the lost parts accumulate.

The technical process was: Single-frame animation of white paper cutouts on a black horizontal surface, photographed on black-and-white stock, Eastman High Contrast Positive Film, Type 5363. The image of the bird was extremely simplified and stylized; the various parts of its body were made with small rectangular bits of paper, occasionally joined but more often left unjoined and kept free from each other to allow flexibility in animating. The color backgrounds which consist of holds, pans and zooms on pastel drawings were shot separately on Eastman Color Negative Film, Type 5248. Color release prints were made by physically superimposing a high-contrast black-and-white duplicate negative of the animation (i.e. a black image on a clear ground) with the color negative of the backgrounds.

Cotton: Nature's Wonder Fiber, produced by Audio Productions, Inc., for Cotton Council International, was chosen by

The new, easy way to lip-synched filming, on location or in the studio is with the

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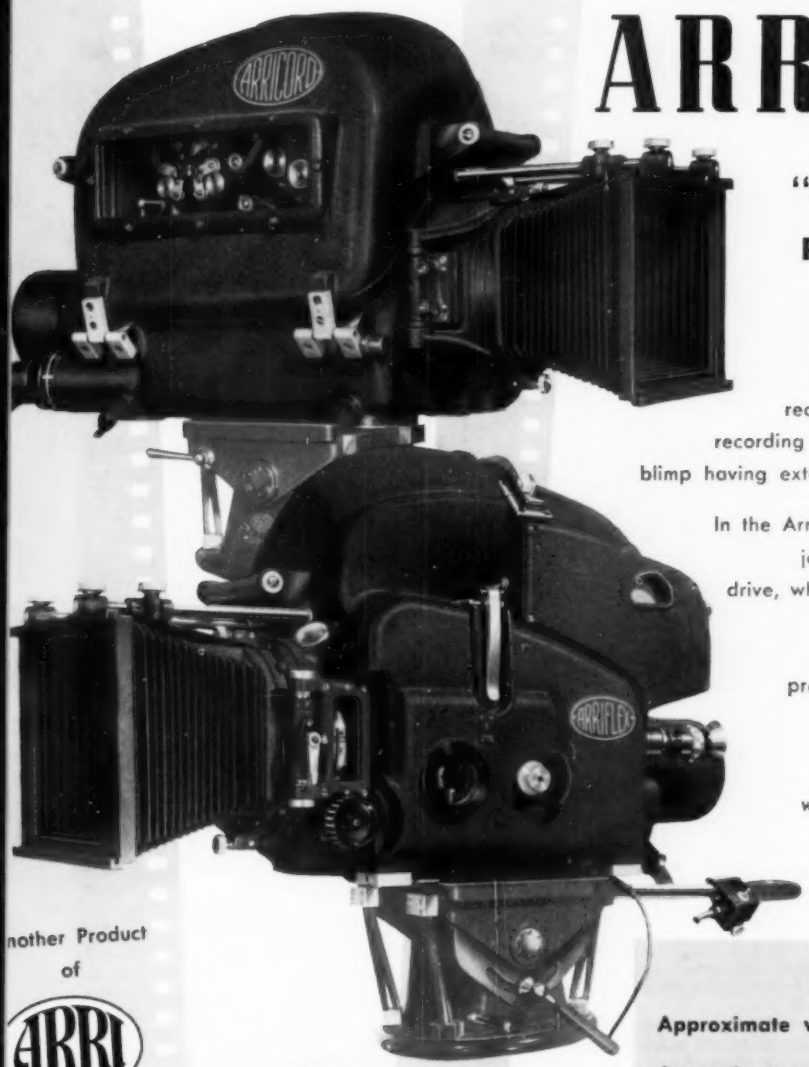

The Arricord 35 is a combination of the latest Arriflex 35mm Model IIB camera and a magnetic recording unit which uses perforated 17½mm magnetic recording film. The combined units are housed in a compact sound blimp having external controls for both sound and picture recording.

In the Arricord, the Arriflex camera component is permanently joined to the recorder unit by a special precision gear drive, which assures constant speed and smooth, even motion in the mechanisms driving both the negative and magnetic films. A 24 Volt governor controlled DC precision motor powers the entire unit.

The Arricord answers the demand for a compact and portable double system sound recording camera with the convenience, money and labor saving features of a single system camera. Because the entire unit is driven by a 24 Volt battery it eliminates the need for AC generators or inverters.

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TECHNICAL DATA

Approximate weight of Arricord	**72 lbs.**
Approximate weight of Amplifier Case	**28 lbs.**
Approximate weight of battery case	**42 lbs.**

Camera part: Same features as Arriflex 35. Three lens turret with remote follow focus and diaphragm drive: 400 ft. magazine capacity. Through the lens focusing and viewing.

Sound part: Made by Klangfilm to professional standards. Takes 450 ft. perforated 17½mm magentic film. Two microphone inputs. 200 ohms. 2 way mixing. Valve metering. Electronic slate and many other features.

Write for complete technical data and specifications.

Available immediately for sale or long term rental with purchase option: 1 Arricord complete with 3 (32-50-75mm) Zeiss lenses matched and coupled, Klangfilm amplifier, batteries, cases as illustrated on left, ready to shoot, $10,000.

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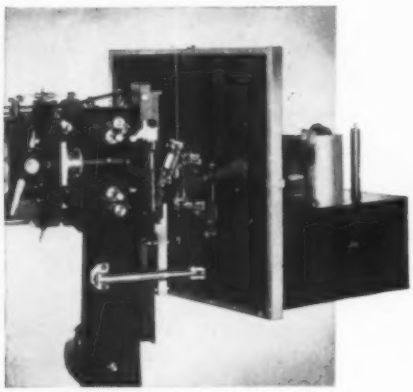
the Committee on International Non-Theatrical Events of the Dept. of Audio-Visual Instruction, National Education Assn., for entry at the Venice International Exhibition, June 10 to November 4, and at the Edinburgh Exhibition, August 24 to September 14. Described as a "superb production," the film uses time-lapse photography to show the growth of the cotton plant and the formation of the cotton boll. The time-lapse sequences were filmed by John Nash Ott. The 27-min color film tells the story of cotton in terms of the agriculturist, the merchant, the spinner, the weaver, the finisher and the textile chemist. The film contains dialogue sequences: English, Italian, German, Spanish, Japanese and French. The non-English portions have titles in English superimposed.

An address on "Fastax Photography, an Engineering Tool," was delivered by Charles A. Jantzen, President of Photographic Analysis Co., Clifton N. J., before the Forum Group of the American Society of Mechanical Engineers, May 8, in the Engineering Societies Bldg., New York. Mr. Jantzen is the author of an article, "What Is High-Speed Motion-Picture Photography," in the Spring 1958 issue of the Eta Kappa Nu magazine, *The Bridge*.



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This 3-light additive color unit supplies discrete blue, green and red beams. No one beam contributes to contamination of the others.

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Three 750-Watt bulbs, operating at 60–80 volts. Assures long bulb life, saving time in calibration.

Adjustable lamp sockets to line up filaments. Three degrees of freedom; vertical, rotational, lateral.

Four-leaf adjustable diaphragm, imaged at the printing aperture which provides an optical printing aperture for exposure and/or uniformity control.

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3-Channel Memory Unit with Reader for automatic operation of flipper assembly, reading in succession blue, green, red and storing the introduced information. 15 neon pilot lights indicate when the 15 neutral density filters are in or out so that operator can see at a glance if Reader and Memory Unit are functioning properly. For easy servicing, commercially available punched tape reader is used as a base. Price: $3,200 F.O.B. New Rochelle, N. Y.

Keyboard and Punch with 32 combinations for each color; blue, green, red; with an additional channel for introducing other information such as stop, lap dissolves, etc., and with built-in scene counter. Can also be used with Reader to reproduce automatically duplicate tapes and will permit corrections of the tape and continue with the accepted information.

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Obituaries

Edward P. Kennedy

Edward P. Kennedy, 62, motion-picture engineer and inventor, died May 27, 1958, at his home in Long Branch, N.J., after a short illness. His contributions to motion-picture engineering include, among others, the invention of a system for synchronizing magnetic tape with perforated motion-picture film (p. 95, Feb. *Journal*). He studied mechanical engineering and design at Case School of Applied Science and at the University of Cincinnati. Early in his career he was employed by Westinghouse Electric Corp. where he invented the oscillating fan. In 1922 he participated in experiments conducted at KDKA Pittsburgh, the first radio station in the United States. Later business associations included Consolidated Edison Co., Electrical Research Products, Inc., Bell & Howell, where his inventions were on the Filmo 16mm motion-picture camera, and DeVry Corp. He had a large responsibility in the development of the JAN 16mm motion-picture projector. While employed as an engineer with Electrical Research Products Inc. he installed many of the early sound systems in motion-picture theaters throughout the United States. Later he became Chief of the Motion-Picture Section, Photographic Branch, Applied Physics Div., Surveillance Dept., USASRDL, Ft. Monmouth, N. J., a post he held for several years. Subsequently he was appointed a member of the Technical Staff of the Photographic Branch.

In addition to his technical achievements, he was the author of numerous articles on engineering subjects. His membership in professional organizations included the Society of Photographic Scientists and Engineers and the Armed Forces Communications and Electronics Association.—*Frank Smith.*

Oscar N. Solbert

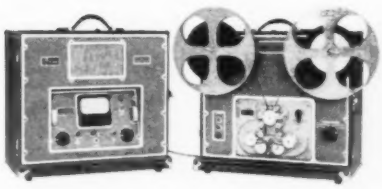
Oscar N. Solbert, 73, Director of George Eastman House, Rochester, N.Y., and a retired brigadier general, died April 16, 1958. A native of Sweden, General Solbert was graduated from the U.S. Military Academy at West Point in 1910 and in World War I served overseas with the Army Intelligence Service. During World War II he served first as executive director of the Office of War Information and later as Chief of Special Services for the Army at the Supreme Allied Headquarters in the European Theater of Operations. He be-

AROUND THE WORLD WITH MAGNASYNC

poona, India

Resting peacefully in a fertile valley, toward the interior of India, is Poona, home of Prabhat Studios, the oldest motion picture facility in the "Jewel of the Orient". Here, Magnasync executives stop on their trip around the world to inspect one of the many International Magnaphonic Sound System installations. Left to right: Mr. Shankarao Damle, Chief Sound Recordist of Prabhat Studios; Mr. S. N. Sengupta of Kine Engineers (Kapila, Sengupta, Rao); Mr. Mohammed, the Chief Cameraman of Prabhat Studios; the actor sitting near the Magnasync Recorders is the well known Indian actor, Mr. Jagirdar.

The severe heat and humidity in India demand that equipment be crafted to perform faithfully under extreme environmental conditions. The popular 35mm "Type 5" has met that challenge and earned an enviable reputation in the expanding Indian film industry. Numbered among the famous studios and producers using Magnasync are:



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SAN FRANCISCO: Brooks Camera Co., 45 Kearney, San Francisco, Calif.; EXbrook 2-7348.
LOS ANGELES: Birns & Sawyer Cine Equipment, 8940 Santa Monica Blvd., Los Angeles 46, Calif.; OLympia 2-1130.
INDIA: Kine Engineers, 17 New Queens Road, Bombay, India.
JAPAN: J. Osawa & Co., Ltd., 5 Ginza Nishi 2-Chome, Chuo-Ku, Tokyo, Japan; Tel: Tokyo 56-8351-5; Cable "OSAWACO."

came associated with Eastman Kodak Co. as a member of the executive staff in 1926, returning there after his World War II service. He served as assistant to the vice-president in charge of sales and advertising in the U.S. and foreign countries. He retired from Kodak in 1949 and following his retirement was appointed director of George Eastman House.

His interest in the Dryden Theater, which adjoins Eastman House, contributed to its present status as an internationally known film center. Together with James Card, Curator of Motion Pictures at Eastman House, he established the George Awards honoring past achievements in motion pictures. One of his major contributions in cooperation with Mr. Card was that of copying early motion pictures which had been filmed on rapidly deteriorating nitrate films.

A part of the testimonial of the trustees of George Eastman House was:

"With the death of General Oscar N. Solbert, the George Eastman House has lost a dynamic leader, whose vision, imagination and enthusiasm brought this institution to a unique position in the world of photography. The Board of Trustees was fortunate to have him, a long-standing friend and co-worker of George Eastman, as the director from its inception of this living memorial to the man who brought photography to all.

"Under the supervision of Oscar Solbert, the George Eastman House became a reality, and its material facilities were rapidly increased by, among other things, a theater, a new exhibition hall, an outstanding collection of motion pictures, and the secure housing of them."

Biographical Note

Ervin R. Geib

Ervin R. Geib, for many years manager of carbon arc sales, retired February 28, 1958, after more than 50 years with National Carbon Co., Div. of Union Carbide Corp. Spanning the history of the industry during the past half century, "Erv" Geib's career started with a job as office boy in September 1907. Working with the people engaged in supplying the motion-picture industry with arc carbons for theater projection and studio set lighting, Mr. Geib became a nationally recognized authority in his field.

Mr. Geib became a member of the SMPTE in 1927 and took an active part in Society affairs, in the course of time attaining the grade of Fellow. For several years he was chairman of the Membership Committee.

His experience in the projection lighting field contributed greatly to the work of the Society's engineering committees. He was a member of the Film-Projection Practice Committee and of the Screen Brightness Committee for several years, and served a two-year term as chairman of the latter.

Mr. Geib's contributions to the professional literature of his field were principally in the *Transactions* of the Society and the *SMPE Journal*. "Carbons for Use With Panchromatic Film," was his first paper, published in 1927, followed by "Improved Reflectors for Motion Picture Studio Side Carbon Arc Lamps," in 1928. In 1934 he published, with D. B. Joy, two papers: "Operating Characteristics of the High-Intensity A-C Arc for Motion Picture Projection," and "The Relation of the High-Intensity A-C Arc to the Light on the Projection Screen." Another paper, "The Non-Rotating High-Intensity D-C Arc for Projection," also written with D. B. Joy, appeared in 1935.

In addition to these and other articles, Mr. Geib was responsible for a sales training manual on "Eveready" sunshine lamps and carbons, and gave numerous lectures during his career on carbon arcs and spectroscopic electrodes. He was also a contributor to the first edition of the "National Projector Carbon Handbook," which is now being reissued in booklet form.—*D.C.*

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4. Stereophonic Reel	Picture with stereo sound and 12,000-cycle control signal on track four	330 ft.*	(ST-1)
5. Flutter Film	3000-cycle, 4-track	50 ft.	(FL-1)
6. Loudspeaker Phasing Film	Signal of uniform level, 400-cycle or 500-cycle frequency-warbled simultaneously on tracks 1,2, and 3, at a 5-cycle rate (specify crossover frequency desired)	50 ft	(LP-1)
7. Constant Level Film	8000-cycle, 4-track to check azimuth	50 ft.	(AZ-1)
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9. Projector Alignment Chart	Picture Only	100 ft.	(PR-1)
10. Projector Alignment Chart—Optical Track	Picture only, standard sprocket holes (made by Motion Picture Research Council)	100 ft.	CSOS

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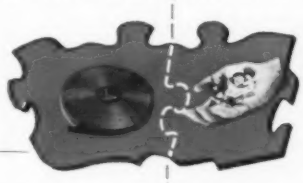

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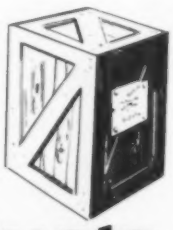

new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Heat-Reflecting Filters in Carbon-Arc Projection Systems

By RUDOLF FISCHER and MARTIN PLOKE

A paper submitted for, but not read at, the Society's Convention at Los Angeles, October 1956, by Rudolf Fischer and Martin Ploke, Zeiss Ikon AG., Kiel Wik, Mecklenburgerstr. 32-36 West Germany. Assistance with the translation of this paper was kindly given by Walter Beyer, Motion Picture Research Council, 6660 Santa Monica Blvd., Hollywood 38.

THE HIGHER amperages required to satisfy screen-brightness standards in wide-screen projection have caused increased heating of film and projector head. In order to obtain highest pictorial quality, each frame should be flat in the projector gate during the projection cycle and not buckled by the heat from the light beam and the hot metallic parts in and around the aperture. Reduction of heat from the arc thus becomes an urgent problem.

Heat filters may be inserted in the light beam at a point where the light cone is still relatively large, so that the specific heat load on the filter area is kept at a minimum. Two types of filters are used, involving different basic principles in their heat-absorbing properties. The older type of filters, once the only kind available, have a slight greenish tint and run very hot since they reduce the heat from the light beam by absorption. They are generally made in strips to avoid cracking due to expansion, and additional air cooling is needed.

Among the more recently developed heat-reflecting filters[1] there are some which absorb no heat, require no cooling, and can be inserted in the light beam like any ordinary lens. Heat-reflecting filters can be made completely colorless or with any color tint desired without affecting the light transmission. An example of the latter type would be heat-reflecting filters made for low-intensity carbon-arc illumination where a bluish-green filter factor is added in order to avoid the bothering orange tone present in the light of low-intensity carbons, which affects the reproduction of color films. As indicated by their name, these filters reflect the invisible heat, which is present in the light beam, back to the light source. This is made possible by means of a special coating

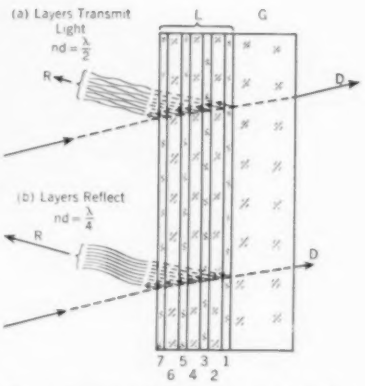

Fig. 1. Cross section of a 7-layer interference filter. L, coating; G, glass support; R, reflected radiation; D, transmitted radiation; nd, optical thickness of each coating.

applied to a glass base. The coating consists of a multiplicity of transparent layers having alternating high and low indexes of refraction.[2]

The effect is based upon the reflection of light on the surfaces of the different layers, which is also accompanied by an interference effect. On this account they are sometimes called interference filters. These filters use the same principle as that of heat-transmitting mirrors.[3,4] Such mirrors have a reflective surface consisting of a coating of layers with interference properties. In general, the layers are much thinner here, but the number used for "cold mirrors" is much greater.

Such mirrors have a high transmission for heat rays, and at the same time have high reflective properties for visible light. Heat-reflecting filters, on the contrary, show excellent transmission for the visible light and a high reflection characteristic for the infrared rays adjacent to the visible spectrum. This is one reason why such heat-reflecting filters are often called infrared mirrors. This basic difference in the operation of cold mirrors and heat-reflecting filters makes it clear that although the coating functions in essentially the same way in both cases, it must be applied in each case with the specific purpose in view for which it is intended.

The relationships between filter and reflection effect are shown in Fig. 1. This is a schematic drawing of an interference coating consisting of seven nonabsorptive layers. The layers with the high index of refraction are marked 1, 3, 5 and 7. The layers with the low index of refraction are marked 2, 4 and 6. Those with the higher index of refraction are thinner than those with the lower index. The reason for this is that to achieve correct optical quality the product of the thickness of the layer, (n), multiplied by the refractive index, d, must be the same for all layers.

If the product nd is about half the mean wavelength of the visible light, for which we will assume the value $\lambda = 0.525\ \mu$, the reflected waves of the visible light will cancel each other, and the coating is transmittant for this wavelength. This is indicated as (a) in Fig. 1.

If, on the other hand, the thickness of each layer and therefore the product nd is

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only half of the above value, or $\frac{1}{4}$ of the mean wavelength, the reflected light will consist of waves of equal phase, and therefore the coating will act as a mirror for $\lambda = 0.525\ \mu$ ((b) in Fig.1). It is thus possible to calculate the characteristic of reflection of such a system in relation to the wavelengths of light.[5,6] If a figure reciprocal to the wavelength, for instance the light frequency, is chosen as an independent variable, a periodical curve with several main reflection maxima, R_1, R_2, etc., will be obtained. These maxima alternate with transmission sections D_0, D_1 and D_2. This is shown in Fig. 2.

If the coating is to act as a filter, the thickness of the individual layers must be such that the transmission section D_1 is shifted into the visible light. In the case of the mirrors, the thickness of the layers must permit the main reflection maximum R_1 to be located in the range of the visible light. Figure 1 indicates what is involved in the composition of such coatings in respect to the number, thickness and refractive index of the layers.

In order to obtain a high degree of light transmission in the case of a filter, the principal concern is to ensure the disappearance of the troublesome band structure in the transmission section D_1. Furthermore, the reflection band R_1 must be extended close to the edge of the visible light. In the case of a mirror, one has mainly to aim for a sufficient height and width of the reflection band R_1, together with adequate elimination of the band structure in the transmission sector D_0. Heat-reflecting filters with a transmission factor of 95% for visible light have been successfully made. These eliminate 50% of the heat rays from the arc lamp. With respect to the total radiant energy of the arc lamp, including the energy of the visible light, and depending on the type of carbons and amperage used, filters give up to 37% effectiveness.

Figure 3 shows the spectral characteristics for two types of such filters as manufactured by Zeiss-Ikon. Curve A represents the clear white Ernotherm filter, and curve B the Ernocolor filter, which has a slight blue-green tint. Both filters are manufactured in the form of disks of 4-in. diameter and 0.118-in. thickness. The manufacture of heat-reflecting filters for use in motion-picture theaters involves not only the dimensions of the individual layers, as described above, but also presents a technological problem. As a carrier or base for the heat-reflecting coating, a heat-resistant glass is generally used, while quartz may be used in special cases. Great care has to be taken in selecting the materials for the interference layers. Most of the known materials will result in relatively soft coatings, which are insufficiently resistant to heat and moisture.

Filters manufactured from such materials can be used only under specific conditions and with adequate precautions. Considerable demands are made on the adhesion of the coating to the glass, since the temperature close to the arc may rise to several hundred degrees during the showing of a reel. During the pause between reels, there is a tendency for condensation of moisture and other atmospheric conditions which tend to deteriorate the coating. Heat may cause pores to form in the layers into which moisture will enter during the cooling cycle.

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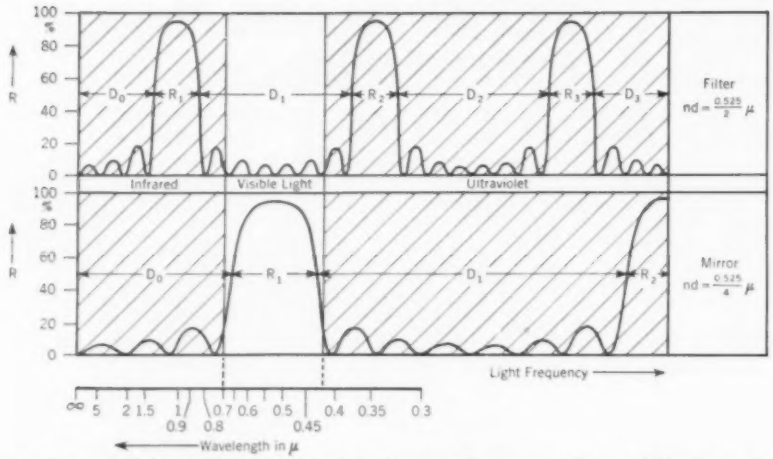

Fig. 2. Spectral distribution plot, showing filter performance with two different coating thicknesses.

When the filter is reheated there is danger of blisters forming, due to the rapid evaporation of the moisture in the pores, and the layer must be destroyed. It is, therefore, essential that these layers should be carefully tested during the manufacturing process for their heat and moisture resistance.

Intensive research and development have now made available heat-reflecting filters which are extremely heat and moisture resistant. Experience in theaters throughout Europe has shown that the Ernotherm and Ernocolor filters fulfill all practical requirements, without need for additional cooling during use. As far as cleaning and maintenance is concerned, no more care is needed than is required for the usual cleaning of optics with antireflective coatings. The Ernotherm colorless filter has done an excellent job in connection with all high-intensity carbon arcs and has contributed notably to the reduction of film buckling due to heat absorption, thus increasing the lifetime of the prints. Such filters can also be used successfully at lower amperages of about 70 amp, at which level noticeable film buckling and flutter can already be observed, tending to produce in-and-out-of focus of the projected image, particularly with short focal-length and high-speed projection lenses. With these filters a steady image with good detail is obtained.

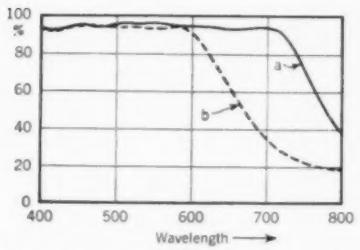

Fig. 3. Transmission curves of heat-reflecting filters; a, Ernotherm filter; b, Ernocolor filter.

Besides the clear white Ernotherm filter, there is also a demand in certain cases for Ernocolor filters with their bluish-green tint. These are used, for example, with low-intensity carbon-arc lamps. Such lamps give orange light which upsets the color balance in the showing of color films.

The transmission characteristic of the Ernocolor filter is shown in curve B of Fig. 3. It has been designed so as to eliminate the disturbing color tint from the low-intensity carbon-arc light. The filter action inherent in the Ernocolor filter does not cause any reduction in its excellent heat-absorption characteristic. Loss or reduction of the visible light has been kept to a minimum.

The effectiveness of this Ernocolor filter in improving color reproduction can best be demonstrated by putting a filter in half the light beam, so that half the image is directly exposed to the low-intensity carbon-arc light, while the other half is projected with light which goes through the filter. The part of the image which is projected by filtered light will show an appreciable improvement in color reproduction, apparent particularly in the white and green colors as reproduced on the screen. Black-and-white films gain as well when projected with light through the Ernocolor filter, because the elimination of the orange color from the light beam causes an apparent increase in contrast on the screen. A loss in screen brightness is hardly noticeable, since light richer in blue-green is physiologically more effective.

In general, it may be concluded that the above heat-reflection filters, with their specially designed transmission curves, will provide screen illumination at a uniform color temperature even with the use of different light sources.

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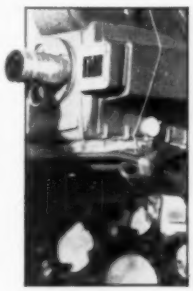

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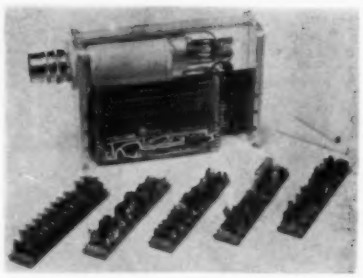

A miniature TV camera described as "the world's smallest" has been announced by Dage Television Div., Thompson Products Inc., Michigan City, Ind., measuring $2\frac{1}{2}$ by $5\frac{1}{4}$ by $7\frac{3}{4}$ in. and weighing about four lb. The camera is completely transistorized and makes extensive use of printed circuits. It is said to equal in performance high-definition TV systems weighing several hundred pounds. Separate potted, plug-in modules handle the six basic camera functions: video amplifier, sweep amplifiers, synchronizing generators, binary strip, power supply and oscillator strip.

The unit includes an automatic electronic light adjustment which compensates for light level changes as high as 250 to 1. For higher changes encountered in airborne uses, servo-driven neutral density wedges provide additional compensation as high as 10,000 to 1, at a speed sufficient to protect the camera's vidicon tube when it is pointed directly into the sun. The camera requires no operating controls for adjustments. Adjustments, such as beam current, target voltage, focus and contrast are made automatically. The camera contains what is said to be the world's first completely transistorized sync generator, which develops a standard broadcast quality EIA sync pulse, with more than 4.5-v output. The entire camera, including the sync generator, requires only 8 w of power and can operate on almost any a-c or d-c power source. It delivers a video signal in excess of 1.5 v.

First deliveries have been made to the Army Signal Corps, Fort Monmouth, N.J. The commercial model is priced at $8000.00.

The New York Central Railroad yards at Elkhart, Ind., cover about 675 acres. Thousands of freight cars daily hurtle about over 72 freight classification tracks, but switching is accomplished in considerably less time and is much less hazardous to railroad workers than before the installation of closed-circuit TV.

Following installation of the RCA closed-circuit system and other automated equipment, railroad officials estimated that freight cars can be speeded through the center in about one-third of the time required before the system was installed. With this equipment one operator in the control tower can direct operations on the 72 tracks that handle up to 3540 cars.

A fixed-focus RCA TV camera is located in a raised housing near each of the yard entrances, two miles apart. As each car passes the camera, its picture is relayed over the closed circuit. The cameras, installed for unattended, round-the-clock operation, are pre-set to scan a 20 by 15-

ft area, and are equipped with automatic iris controls and automatic target adapters to permit electronic adjustment for changing light conditions. The system includes video line amplifiers with a suppressor of induced noise, designed to assure a clear picture, unaffected by power lines or other sources of distortion.

Automatic programming equipment designed for a TV station break was demonstrated at the NAB Convention, April 28–May 1, at Los Angeles, by Radio Corp. of America. The system can handle a program consisting of ten events, with a possible expansion to a maximum of 20 events. The system's memory unit employs binary relays and stepping switches to store information, including the time required for the individual program event, the audio or video source (film camera, record turntable or slide projector) and the event number in the program sequence. The relays and switches are mounted in a standard cabinet rack with a timer and the necessary power supplies. The operator sets up the desired program sequence by pressing the proper "event select" buttons. Events of any desired length can be selected by use of a time selector switch. Another switch on the control panel permits the operator to scan the system's memory system for errors or to locate a particular event in which changes are to be made.

An exposure time of 0.01 μsec is reported achieved with a Kerr cell electrooptical shutter and pulse generator circuit developed by the Research and Advanced Development Div. of Avco Mfg. Corp., 20 S. Union St., Lawrence, Mass., especially for ballistics photography. The pulse generator consists of RG8/U coaxial cable and a specially designed spark gap to provide the required driving signal. The Kerr cell is connected directly across the load resistor on the transmission line and does not require an impedance matching network or pulse transformer.

The electric field needed to produce phase rotation of the electromagnetic light vector as it passes through the nitrobenzene-filled cell lies between 10 to 15 kv/cm. Thus, a pulse generator for a 5-cm. aperture must deliver a pulse of 50 to 75 kv to the Kerr cell plates. Exposure time can be varied from 0.01 to 0.1 μsec by changing the length of the transmission line used in the pulse generator. The waveform for the exposure characteristic is nearly that of a square-wave.

The spark gap used on the pulse generator is designed to minimize effects of corona leakage and atmospheric variations on the trigger characteristic. It may be modified for shadowgraph or schlieren photographs to provide a point light source that is synchronized with the opening of the Kerr cell. Original work on the pulse generator was performed at Los Alamos Scientific Laboratory under the auspices of the Atomic Energy Commission. The shutter has been used in aerodynamic simulation studies of long-range missile re-entry problems.

A device called Audipage which fits on an instructor's ear has been developed by Philco Corp. to facilitate two-way communication in closed-circuit applications. First used in a demonstration at Perth Amboy General Hospital, Perth Amboy, N. J., as part of an experiment in the use of closed-circuit TV in nursing education, the study was conducted as part of a freshman clinical conference. The student nurses were able to question the instructor as his bedside discussion of a patient's case was presented in the classroom on TV. The questions could be heard by the instructor through the device without being heard by the patient. Personnel and equipment for the experiment were provided without cost to the hospital by Impco Inc., Philco Industrial Television representative in New Jersey, New York and Connecticut, and by Consultant Associates, Inc., Long Branch, N. J.

Almost a hundred types of precision wire-wound resistors are listed in the 20-page illustrated catalogue, 14RC, issued by Cinema Engineering, 1100 Chestnut St., Burbank, Calif. Since the last catalogue was issued, certain resistor series have been renumbered to conform with a new specification pattern. Requests for the catalogue should be addressed to the company to the attention of James L. Fouch.

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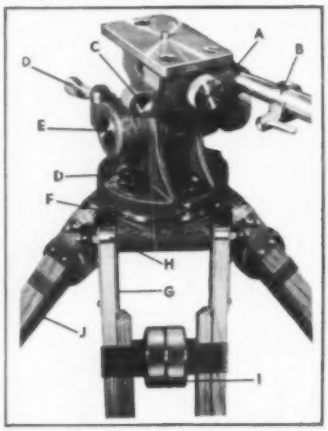

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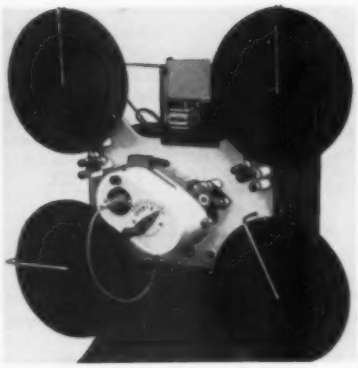
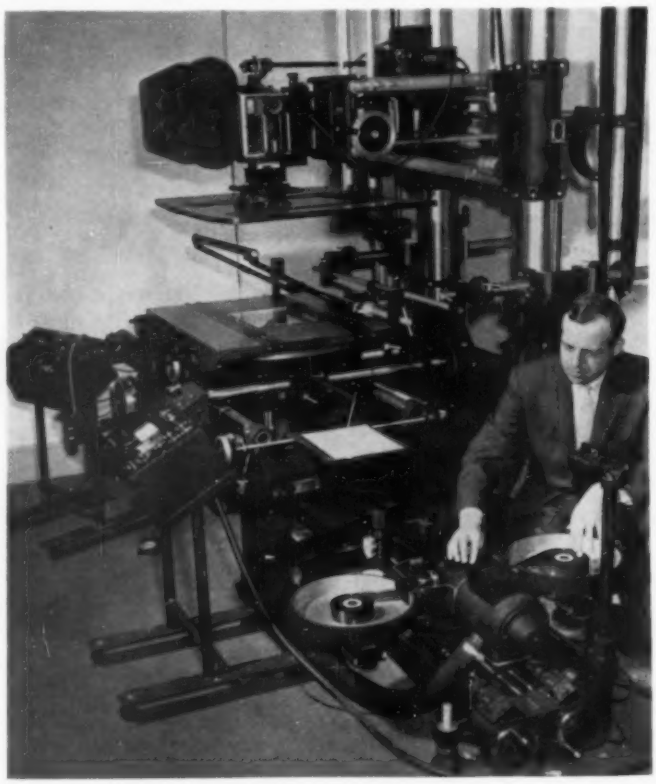


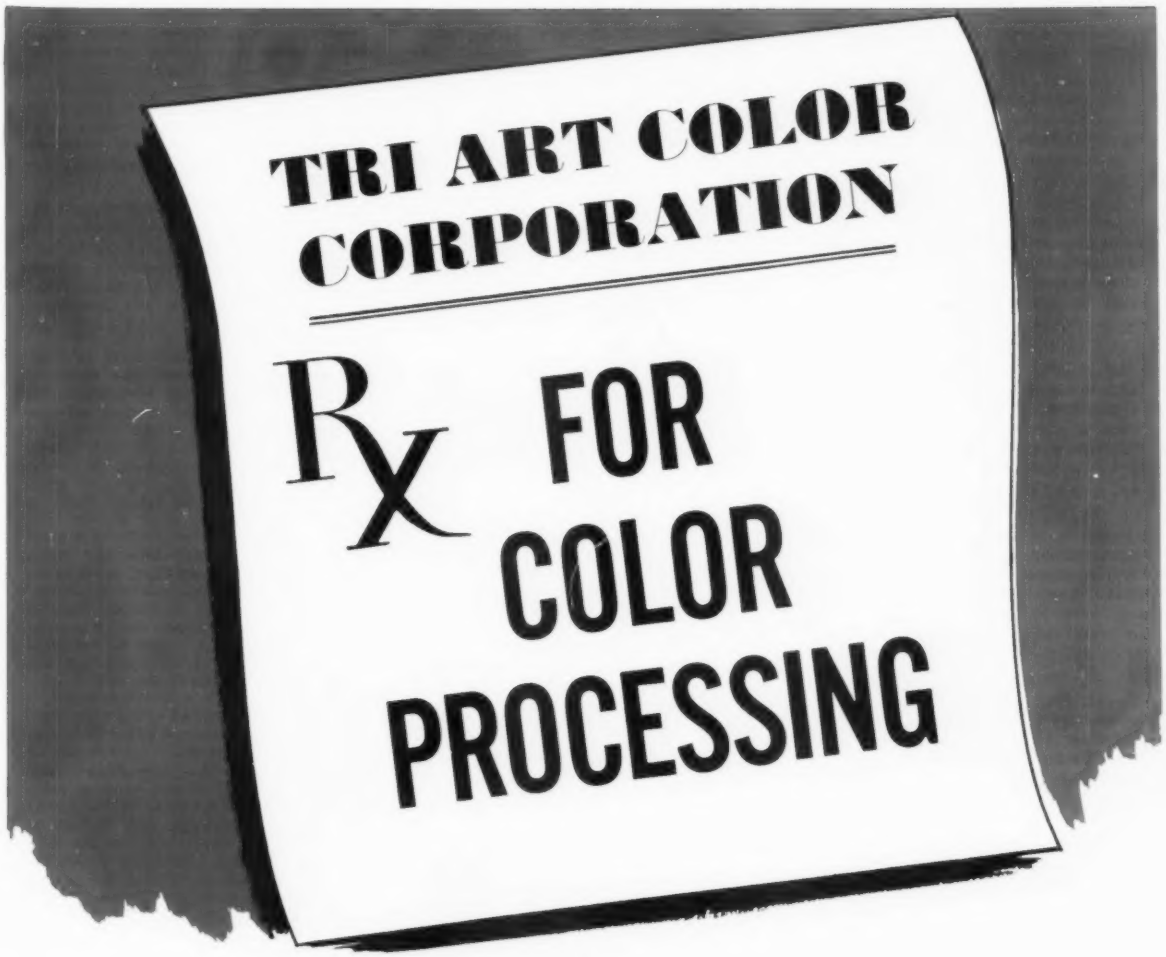
The Tel-Amatic 16mm printer has been announced by S.O.S. Cinema Supply Corp., 602 W. 52 St., New York 19. Features include semiautomatic 13-scene mechanical light change, separate feed and takeup sprockets, and 3-way aperture for sound, picture and composite. The machine has a 1200-ft capacity and a speed of 43 ft/min. It has been designed with a 40-tooth printing sprocket for proper registration. The lamp is 6-v, 4-amp, S.C.B. The lampholder accommodates CC filter for color printing. The printer is supplied ready for bench or table mounting at the price of $1495.00 or mounted on a heavy floor pedestal for $1650.00.

Artiscope, described as "illustration in animation by automation," is an animation technique introduced by Illustrated Films Inc., 8460 Santa Monica Blvd., Hollywood 46, and described briefly as a new film technique in the firm's brochure. The firm explains this method of animation as a process of first photographing a "live action" record of people and props on 35-mm film and then converting the images to inked drawings on celluloid by a series of electrochemical procedures. This method is said to effect fully animated illustrations at a cost lower than that required by conventional animation techniques.

Charles Beseler Co., East Orange, N.J., has purchased Projection Optics Co., Rochester, N.Y., manufacturers of lenses and precision optical equipment, from Fred E. Aufhauser. Operations will continue in the Rochester plant under the direction of Philip Berman, who has been appointed President of the newly purchased firm.



An Oxberry animation stand with a specially designed aerial image rear-projection unit has been purchased by Alpha Film Studio (Pty Ltd.), Johannesburg, South Africa, from Animation Equipment Corp., 38 Hudson St., New Rochelle, N.Y. The aerial image feature converts the equipment into a vertical optical-effects printer. It consists of a projector head, lens mount, stop-motion motor and controls, a flat surface mirror and a large condenser lens system. The stop-motion motor runs continuously forward and reverse and operates independently of the animation camera stop-motion unit, permitting skip-frame work for lengthening or shortening scenes. The unit was built as an integral part of the South African installation, but it can be obtained separately and attached to other Oxberry stands.



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Transistor action at a semiconductor/electrolyte interface modulated by an electrical field has been described by Bell Telephone Laboratories in a paper by J. F. Dewald before the American Physical Society. Recent laboratory experiments have demonstrated amplifier operation at 1000 cycles/sec with gain in excess of 15 db.

The experimental device uses a hexagonal rod-like crystal of very pure zinc oxide as the semiconductor, immersed in a highly conducting electrolyte. A platinum electrode placed nearby serves as the grid element. Because zinc oxide is a large-energy-gap semiconductor, it can be operated in a high enrichment condition, with one end of the crystal cathodically biased with respect to the solution, and the other end anodically biased. Somewhere in between is a neutral point which is unbiased, where the energy bands are flat right up to the surface of the crystal. As this neutral point shifts back and forth under the influence of varying biasing grid voltages, the resistance of the crystal changes, passing a current which follows the driving frequency very closely. A fairly extended range of linear response is obtained.

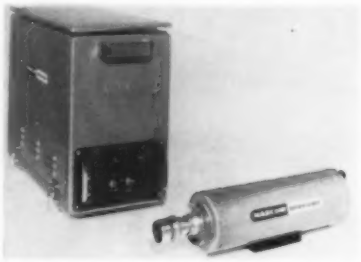
To make electrical contact to the zinc oxide crystal, the two ends are first indium-plated to assure good ohmic contact. They are then copper-plated to allow soldering copper wire leads. The platinized platinum grid completes the assembly. After insulating all wires and connections except the grid, the assembly is immersed in the electrolyte (5% sodium tetraborate and boric acid solution), and hermetically sealed in a small glass tube to avoid electrolyte evaporation.

The Yashica 8, and Turret 8 (Progress Report, *Journal*, May 1958, p. 332) are available in the United States through Jack Gilbert Associates, 1186 Broadway, New York 1, N.Y., at prices of $49.95 and $79.95, respectively. The Turret 8 features a two-lens turret and is available with a normal 13mm, a 3× true 38mm telephoto and a wide-angle 6.5mm lens. The motor has seven running speeds: 8, 12, 16, 32, 48 and 64 frames/sec. The 8 has many similar features but runs at only 16 frames/sec.

The Magneloop series of continuous-loop magnetic tape recorders-reproducers is described in a 4-page folder available from Amplifier Corp. of America, 398 Broadway, New York 13. Descriptions of 21 basic models available in single or dual speeds and in single, dual and triple channels are included.

A new booklet, *16mm Kodak Movie Films — Data and Selection*, gives advice on loading, film storage, processing, duplicating, use of magnetic sound coating and explains the use of various types of film such as reversal or negative, color or black-and-white. A special data section contains complete exposure information and explains exposure compensation when using filters. It is available without charge from Eastman Kodak Co., Sales Service Div., Rochester 4, N.Y.

An electric slide changer, Model 6800, has been announced by Genarco Inc., 97-04 Sutphin Blvd., Jamaica 35, N.Y. The slide changer accommodates 70 glass-mounted or Polaroid slides, 3¼ by 4-in., and can be mounted on most makes of slide projectors. It operates by pushbutton remote control. It is priced at $285.00.



The Canadian Marconi Co., P.O. Box 1480, Station "O", St. Laurent, Que., Can., has announced a new Industrial Vidicon Camera Channel, Type BD-871. The cylindrical camera head, which is about 4 in. in diameter, has a single lens for a variety of fixed lenses; or a zoom lens and focus can be remotely controlled. This camera chain was described in the Progress Report (*Journal*, p. 322, May 1958) but was inadvertently referred to as the BD-835A which is an earlier, and now obsolete, model of the company's industrial camera chains.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Sound man desires position, preferably with educational or technical film producer. 3 yr college, 3 yr technical schooling, 4 yr motion-picture and general sound recording on film, tape, and disk. Experienced in recording, editing, mixing; sound equipment design, installation, repair. Have musical training and experience. Have own tools and test equipment. Age 25, unmarried. Will relocate. For detailed résumé, write: Donald A. Johnson, 700 Prentis, Apt. 403, Detroit 1, Mich.

Sound Recording. Young man, 7 yr specialized experience film recording, scoring, mixing, sound editing; 4 yr intensive musical recording, tape, disc. Wide knowledge of music background material and selection. Prefer NYC location. Address: Sound Recorder, c/o Apt. 2-C, 51 Paulus Blvd., New Brunswick, N.J.

Motion-Picture or TV Studios, Young man (25) acquainted many phases of photography, filmstrip and slide production; 5 yr experience in motion-picture production, employed by Audio-Visual Service USOM/L, c/o American Embassy Beirut, Lebanon, as Program Advisor II. Experience in planning, budgeting, scheduling, purchasing and training. Worked as cameraman-director, editor of educational, documentary training and newsreel films in 16 & 35mm B & W and color. Consider any position along lines of above experience. Write: Hrayr B. Toukhanian, c/o 714 Glenwood Avenue, Syracuse 7, N.Y.; Tel: GRanite 5-4614.

Cameraman-Director-Editor. College background in all phases 16mm production; 2 yrs experience with college film production units. Desires position with commercial or industrial film producer. Will travel or relocate. Single, age 27. Have films, clips, will send resume. Write: E. B. Fleischer, 217 Hillside Ave., Cranford, N. J.

Rhodesian Producer-Cameraman visiting the U. S. October/November to examine latest motion-picture techniques, processes and equipment, offers knowledge gained during 20 yrs experience all branches film making in primitive Africa to interested organisations. Please write air mail to Geoffrey Mangin, Central African Film Unit, P. O. Box 1184, Salisbury, Rhodesia, Africa.

Optical Effects Company owner and operator seeks change. Over 8 years experience in opticals and effects work. Familiar with all phases of processing, editing and production. Have also worked as motion picture theatre manager. Willing to relocate. B.A. in Business Administration. Age 32. Reply to: Occupant, Apt. B-32, 796 Bronx River Rd., Bronxville, N.Y.

Ambitious Photographer, twelve years experience, stills and motion pictures. Three years Audio-Visual Department, San Diego City Schools. Two years news photographer, editor and writer for NBC affiliate television station. Presently employed by small production unit shooting TV commercials, news features, and industrial films. Desires opportunity to do creative quality work with future in production organization, television station or industrial firm. Resume upon request. David Bash, Apt. 2, 2826 Mission Blvd., San Diego 8, Calif.

Motion-Picture and TV Equipment. Presently employed with leading firm supplying equipment and technical service throughout the world; thoroughly familiar with all types of equipment and manufacturers; background as free-lance cameraman. Desire position with active organization supplying equipment or sales representative for manufacturer desiring east coast branch. Available mid-August. Barry Green, 1672 Ocean Pkwy., Brooklyn 23, N. Y. Tel: DEwey 6-2454 after 8 p.m. Mon-Tue-Wed.

Motion-Picture Production. Graduate Brooks Institute, MP course, thoroughly experienced in all phases of camera work, editing, optical and magnetic sound recording, and still photography. Produced industrial and educational films, TV commercials. Familiar with B&W processors. Seeking permanent position or temporary assignments. Free to travel, speak several languages. J. C. Klopping, 312 W. Yanonali St., Santa Barbara, Calif. Tel. WOodland 6-1482.

Cameraman-Editor. Would like to join young progressive film-making organization, foreign expedition or exploration party. Recently discharged from Pictorial Branch, U. S. Army Signal Corps. Experienced in sound recording, laboratory and other phases of the motion-picture field. Age 22, single, free to travel. References and complete resume on request. H. LeRoy Mills, 427 Cherry Ridge, San Antonio, Texas. Tel: DIamond 4-6583.

Studio Engineer. Young man (22), vet., graduate of Studio Training Course—TV Workshop, top scholastic man in class; thoroughly qualified audio engineer, TV cameraman, floor manager, video operator, with knowledge of scenery, special effects, lighting, color TV principles and

operations; FCC phone license. Willing relocate anywhere; complete resume on request. Martin Morris, 771 West End Ave., New York 25. Tel: MOnument 6-4962.

Positions Available

Sales Repr. — Customer Relations. Well-established, moderate-sized motion-picture laboratory with excellent reputation for quality work, both B & W and color, planning expansion program for area's growing demand. Excellent opportunity for qualified man having thorough knowledge of all phases of film processing as well as experience in customer relations and in new business development. Write Kenneth Reames, 1380 National Bank Bldg., Detroit, Mich., giving qualifications and experience and salary range.

Electronic Technician. U.S. Civil Service Commission Announcement No. 151B. Installation and maint. electronic equip. such as computers, detectors, testing and communication, also res. & dev. Grade GS3 through GS12. Salary $3175.00 to $7570.00. No written test. Apply to Executive Secretary, Board of U.S. Civil Service Examiners, National Bureau of Standards, Washington 25, D.C. Application forms available from post offices and from U.S. Civil Service Commission, Washington 25, D.C.

Chemical Engineers. Young progressive res. & dev. firm in the field of graphic information collection, storage and retrieval for use. Must have B.S. degree or equivalent and 2–4 yr experience in photo-chemistry, preferably processing techniques. Write qualifications and experience to W. R. J. Brown, ITEK Corp., 700 Commonwealth Ave., Boston 15, Mass.

Senior Physicists. Young progressive res. & dev. firm in the field of graphic information collection, storage and retrieval for use. Must have M.S. degree or equivalent and 7 or more yr experience in photo-optical design or 5 yr experience in photography with emphasis on image evaluation. Write qualifications and experience to W. R. J. Brown, ITEK Corp., 700 Commonwealth Ave., Boston 15, Mass.

Sound Engineer. Expanding 16mm film prod. company and laboratory wants man to take over its sound recording dept. Must have electrical engineering background, with thorough knowledge 16mm optical film recording using Maurer equipment. Work involves studio and location recording on ¼-in. tape and 16mm magnetic equipment, mixing magnetic tracks to master magnetic or optical tracks, some disk recording, installation of new equipment, maintenance, etc. Experience in some or all phases of 16mm laboratory and prod. work essential. In application give age, education, experience, & salary requirements. Western Cine Service, Inc., 114 East 8th Ave., Denver 3, Colo

Film Inspectors. Temporary or permanent. Write or call Peerless Film Processing Corp., 165 W. 46 St., N.Y. 36. Tel: PLaza 7-3630. Att: Kern Moyse.

Industrial Film Writers, Cameramen, Editors. Experienced industrial writer-directors, cameramen, and editors are needed for film production on aircraft and advanced projects at San Diego, Calif. Writers should have college degree and 3 to 5 yrs experience in industrial film production. Cameramen should be experienced with standard 35mm and 16mm production techniques, including sync-sound and set lighting. Editors should be experienced with all lab and editing techniques, including ability to direct dubbing sessions. Applicants should list all personal data, including past experience, employers, and salary requirements. Salary commensurate with experience and ability. Contact R. M. Hall, Motion Picture Section, Building 19, Convair, A Division of General Dynamics Corporation, San Diego, California.

Aircraft Motion-Picture Supervisor. To supervise complete in-plant production of engineering and technical films, including script preparation, directing, cinematography, sound, editing, animation and printing operations. Experience preferred in producing films related to aircraft and/or missiles programs, primarily to meet contract requirements under Air Force Table 210. Must be highly creative and imaginative in conception and execution of films in this field. Personable, tactful individual required, capable of dealing effectively with people at all levels. Write qualifications and experience to: E. Stanton Brown, Engineering Administrative General Supervisor; Convair, A Division of General Dynamics Corp., Fort Worth, Texas.

Sales and Applications Engineers, for photographic instrumentation firm selling airborne and ground data-recording equipment. Experience in aircraft and missile test instrumentation field, with optical and electronic background most desirable. Some travel required western U. S. Please address initial inquiry with brief outline of background to: Mark Macintosh, V. P., Traid Corp., 17136 Ventura Blvd., Encino, Calif.

Theatre Sound Engineer. Must have good technical background and be experienced in theatre sound work. We are expanding. Applications will be treated with strictest of confidence. North West Sound Service, Inc., 73 Glenwood Ave., Minneapolis 3, Minn.

Laboratory Quality Control. Requires thorough experience in sensitometric control methods for B&W and color raw stock (print, sound recording and camera) and developing processes. Knowledge of chemical test procedures for processing formulae and operation of temperature control systems. Ability to judge picture and sound quality. Position will be as assistant to Manager in a rapidly expanding laboratory. Send complete resume of professional background, education and salary requirements to: Dana C. Rogers, Southwest Film Laboratory, Inc., 3024 Ft. Worth Avenue, Dallas 11, Texas.

Senior Electrical Engineer (Arc and Plasma Specialist). Requires background of theoretical and experimental work in the field of high intensity electric arcs and plasma research. Development of practical devices based on arc and plasma technology in a wide range of power. Position offers an opportunity to perform research and development in association with distinguished research personnel; excellent salary and opportunity for professional growth. Laboratory located in Orange County, Calif., 10 miles from Pacific Ocean, 40 miles from downtown Los Angeles. Send resume to Giannini Plasmadyne Corp., P.O. Box 1199, Santa Ana, Calif.

Optics Engineer. Chief of section engaged in photographic and optical support of military video reconnaissance program. Knowledge of photographic sensitometry, processing techniques and geometric optics essential. Reconnaissance systems background and mechanical design experience on aerial cameras or motion-picture apparatus desired. Location—Stamford, Conn. Write: CBS Laboratories, 485 Madison Ave., New York 22. Att: H. P. Munday.

Cameraman. Duties primarily as 16mm cameraman with some work in sound and editing. College production unit engaged in producing 16mm sound and color films of an educational nature. Entrance salary $4704 per year. Send resume of background, experience and references to Norman E. C. Naill, Production Supervisor, V.P.I. Motion Picture Unit, War Memorial Hall, Blacksburg, Virginia.

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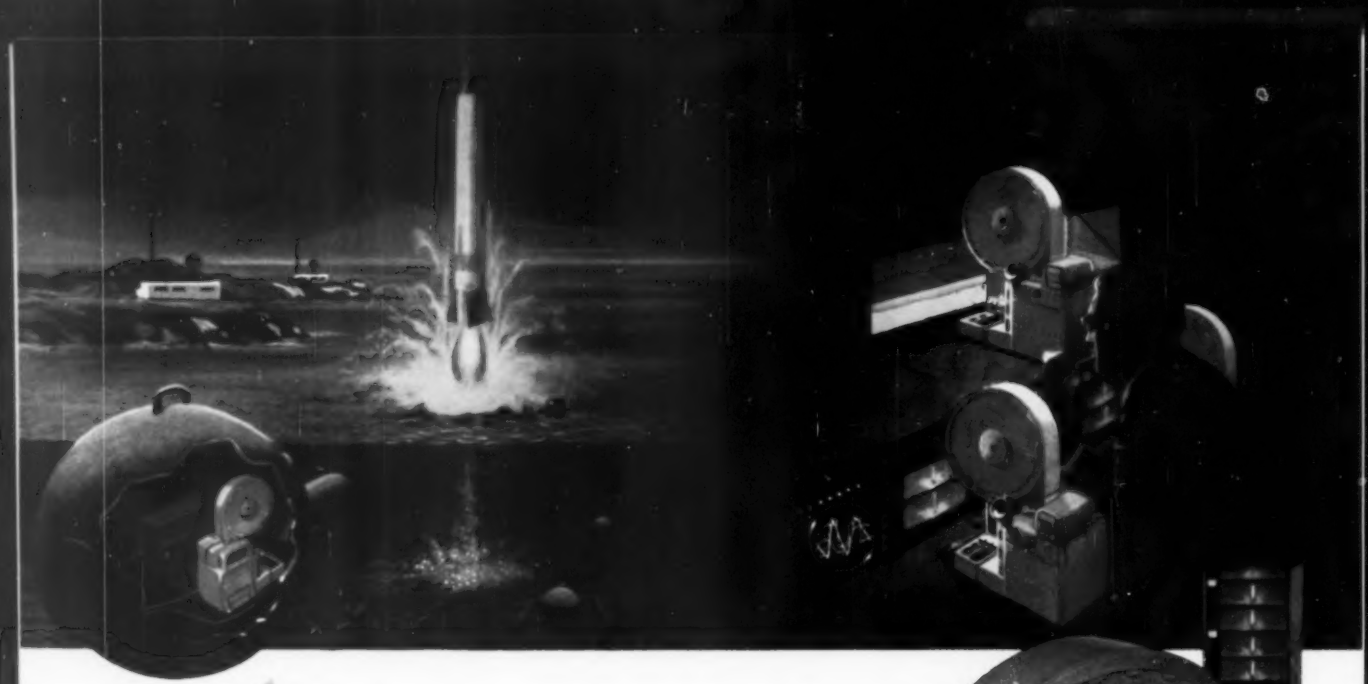

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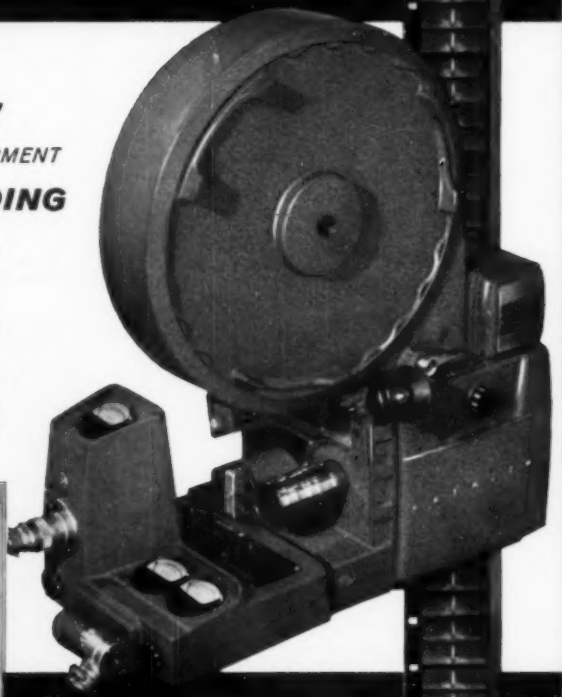

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Meeting Calendar

National Industrial Photographic Conference, July 21–25, Conrad Hilton Hotel, Chicago

National Audio-Visual Association, Annual Convention, July 26–29, Morrison Hotel, Chicago.

AIEE, Aug. 6–8, at the Hotel Statler, Los Angeles. Nonlinear Magnetics and Magnetic Amplifiers Conference.

National Bureau of Standards, Aug. 13–15, Boulder, Colo. Electronic Standards & Measurements Conf., sponsored by AIEE & IRE, National Bureau of Standards, Boulder Labs.

National Technical Conference, Illuminating Engineering Soc., Aug. 17–22, Royal York, Toronto.

Biological Photographic Assn., Aug. 18–21, at the Shoreham Hotel in Washington, D. C. Will feature award-winning display of transparencies, prints and motion pictures.

International Conference on Semiconductors, sponsored by IUPAP, AEC, NSF, AFOSR, ONR, Aug. 18–22, U. of Rochester, Rochester, N.Y.

WESCON, Aug. 19–22, Ambassador Hotel, Los Angeles.

American Physical Society, Aug. 26–28, Vancouver, B.C., Canada.

Instrument-Automation Conference, Sept. 15–19, Convention Hall, Philadelphia.

National Symposium on Telemetering, Sept. 22–24, Americana Hotel, Miami Beach, Fla.

Standards Engineers Society, Sept. 22–24, Benj. Franklin Hotel, Philadelphia.

Fourth International Congress on High-Speed Photography, including Equipment Exhibit, Sept. 22–27, Cologne.

Society of Photographic Scientists and Engineers, Annual Technical Conference, Oct. 6–10, Manger Rochester Hotel, Rochester, N.Y.

Optical Society of America, Oct. 9–11, Hotel Statler, Detroit, Mich.

U.S. National Commitee of the International Commission on Illumination (C.I.E.) Annual Meeting, Oct. 13–14, Lion Inn, State College, Pa.

National Electronics Conference, Oct. 13–15, Hotel Sherman, Chicago.

IRE Canadian Convention, Oct. 15–17, Exhibition Park, Toronto, Canada.

84th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 20–24, Sheraton-Cadiliac, Detroit.

AIEE, Fall General Meeting, Oct. 26–31, Penn-Sheraton Hotel, Pittsburgh, Pa.

American Standards Association, Ninth National Conference on Standards, Nov. 18–20, Hotel Roosevelt, New York.

Acoustical Society of America, Nov. 21–23, Chicago, Ill.

American Physical Society, Nov. 28–29, U. of Chicago & Hotel Windermere, Chicago.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–9, 1959, Statler, New York.

87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.

88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D. C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, Statler, New York.

Journals Available/Wanted

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Issues beginning in 1953 available on a nominal basis. Write: Mitchell M. Badler, 1711 Davidson Ave., Bronx 53, N.Y.

Jan. 1930 through Dec. 1937; Journal SMPE issues; and Jan. 1930 through Dec. 1935, bound volumes of SMPE Journal; SMPE Transactions: Apr. 1919:8, May 1920:10; May 1922:13; Oct. 1922:15; May 1925:21; Oct. 1925:24; Apr. 1927:30; Sept. 1927:32; Apr. 1928:33; Sept. 1928:36; SMPE Membership Listings: 1928, 1930, 1938; SMPE Index and Authors: 1930–1935; SMPE Miscellaneous: ASA Z22—1930; Dim Stab of M.P. Films 1934; ASA Z22—1935; High Intensity Lamps—1935; Program Spring Convention Apr. 26, 1939. Write John Faber, 5 Edgewater Drive, Denville, N.J. Phone Rockaway 9-2623M.

Complete set of Transactions, except Nos. 6 and 9, and all Journals published to date, including indexes. All in good condition. Price $500. W. W. Hennessy, RFD #2, Pound Ridge, N. Y.

Complete set of Journals from May 1937 to June 1954, including special volumes and membership directories, excellent condition; also Mar., May 1934 and July 1935 issues. Write: Harry R. Lubcke, 2443 Creston Way, Hollywood 28, Calif. HO 9-3266.

Wanted

Jan. 1938. E. Raymond Arn, Film Associates, Inc., 4600 S. Dixie Ave., Dayton 9, Ohio

High-Speed Photography, Vols. 2 & 3. Morton Sultanoff, Terminal Ballistics Laboratory, Aberdeen Proving Ground, Md.

High-Speed Photography, Vols. 1, 2 & 3. John H. Waddell, Fairchild Camera & Instrument Co., 5 Aerial Way, Syosset, N. Y.

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DeLuxe Laboratories, Inc.
Desilu Productions, Inc.
Dominion Sound Equipments Limited
Du Art Laboratories, Inc.
E. I. du Pont de Nemours & Co., Inc.
Dynamic Films, Inc.
Eastman Kodak Company
Elgeet Optical Company, Inc.
Max Factor & Co.
Fordel Films, Inc.
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Frank Herrnfeld Engineering Corp.
Hollywood Film Company
Hollywood Film Enterprises Laboratory
Houston Fearless Company
Hunt's Theatres
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
The Kalart Company, Inc.
  Victor Animatograph Corporation
KINTEL (Kay Lab)
Kling Photo Corp. (ARRI Div.)
Kollmorgen Optical Corporation
Lorraine Orlux Carbons
J. A. Maurer, Inc.
  Precision Film Laboratories, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Products, Inc.
  Columbia Pictures Corporation
  Loew's Inc.
  Paramount Pictures Corporation
  RKO Radio Pictures, Inc.
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Amusement Co.
National Theatre Supply
Neighborhood Theatre, Inc.
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Prestoseal Mfg. Corp.
Producers Service Co.
Radiant Manufacturing Corporation
Radio Corporation of America
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
Charles Ross, Inc.
S.O.S. Cinema Supply Corp.
Shelly Films Limited (Canada)
Southwest Film Laboratory, Inc.
Technicolor Corporation
Titra Film Laboratories, Inc.
Trans-Canada Films Ltd.
Van Praag Productions
Alexander F. Victor Enterprises, Inc.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
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